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THESIS

COST AS AN INDEPENDENT VARIABLE IMPLEMENTATION ISSUES

by

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March 1997

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This thesis will examine challenges defense department managers face when implementing the cost as an independent variable (CAIV) concept of cost control. The CAIV concept replaces the design-to-cost (DTC) concept which only achieved limited success. Emphasis is placed on identifying issues that managers faced implementing the DTC concept. These issues are analyzed to determine the potential cause of the issue and the impact the issue may have on programs implementing CAIV.

It is the contention of this thesis that the CAIV concept and the DTC concept are in theory, virtually identical. Many of the same issues will surface during CAIV implementation that managers faced implementing DTC. CAIV may become another ineffective cost control measure. However, DTC was not usually implemented as intended by the guidance. In addition, acquisition reform has provided the manager implementing the CAIV concept significant advantages over previous managers. With full management support, programs implementing the CAIV concept can succeed and provide cost effective systems that meet the needs of the user.

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COST AS AN INDEPENDENT VARIABLE IMPLEMENTATION ISSUES

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Submitted in partial fulfillment of the
requirements for the degree of

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from the

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I. INTRODUCTION

A. OVERVIEW

The declining defense budget and the end of the Cold War have caused the Department of Defense (DOD) to place a renewed emphasis on cost control. The priority that top DOD leadership places on cost reduction is emphasized by the Under Secretary of Defense Paul Kaminski in the 1995 memorandum entitled, "Reducing Life Cycle Costs for New and Fielded Systems." Kaminski stated, "Reducing the cost to acquire and operate the Department's equipment while maintaining a high level of performance for the user is my highest priority." [Ref. 1: p. 1]

Over the years, the DOD has implemented a number of programs with the objective to better manage and/or reduce acquisition costs, including design-to-price, design-to-cost (DTC), design-to-life-cycle cost (DTLCC), value engineering, and Program Baseline agreements. These programs have resulted in some degree of cost control. However, costs generally have increased, resulting once again in the Military Departments and Services facing budget shortfalls.

Further evidence of the importance of life cycle cost can be seen from the emphasis placed on cost control in the update of the DOD 5000 series documents. One of the six major themes, described in DOD 5000.1 and DOD 5000.2-R, that define the new acquisition environment is cost as an independent variable (CAIV). Program managers must use the CAIV approach throughout the acquisition lifecycle.

B. OBJECTIVES AND BENEFITS

This thesis will benefit program managers throughout the DOD by explaining the concept of CAIV and developing recommendations to overcome implementation issues. The concept of CAIV must be included as part of the development process, yet has not been fully explained in available documents. Unlike past initiatives, comprehensive directives or guides are not included as part of the implementation process guidance. The concept of CAIV is not fully understood by many within the acquisition process.

The CAIV concept is described as a new approach to cost control based on industry practices. In the preface to a 1995 CAIV Working Group Paper, the Principal Deputy Under Secretary of Defense, Acquisition & Technology, R. Noel Longuemare stated:

> For years the non-defense sector has successfully developed and produced high quality products that fully meet or exceed customer needs, while also meeting specific, predetermined cost targets for these products. The thrust of CAIV adapts these successful practices to meet DOD needs. [Ref. 2]

Kaminski similarly declares, "CAIV is the DOD equivalent of best commercial business practices." [Ref. 1:p. 1] It appears successful CAIV implementation could be achieved by studying industry methods.

The comparison of a DOD cost control program to non-defense commercial or industry practices is not new. The earlier DTC concept was compared to existing

commercial practices. In 1974, an article providing a DTC overview in a special DTC issue of the Defense Management Journal stated:

> To industry, design to cost is not a new concept. It has been used by many manufacturers of commercial products, ranging from radios to automobiles. Managers and engineers in commercial industry are generally well aware of the production item cost target which must be achieved if the product is to be competitive. [Ref. 3:p. 3]

There are many other references to commercial practices. The keynote speaker for the 1976 DTC Conference was the Deputy Assistant Secretary of Defense (Material Acquisition), Jacques Gansler. He described the relationship in his opening comments by stating, "design-to-cost principles encompass the application of relatively common sense commercial practice to DOD systems acquisition." [Ref. 4:p. 1]

Although there are a number of DTC success stories, the DTC program never achieved widespread success as a cost control program. In 1995 the DTC military standard was canceled and CAIV became the new cost control concept.

The primary goal of this research is to identify CAIV implementation issues and develop recommendations to address the issues. The research will examine the DTC program implementation process to identify similarities to the CAIV concept. This part of the research will form the basis for the analysis by developing issues that must be resolved before the Services can implement CAIV. Recommendations will be developed to address CAIV issues.

C. RESEARCH QUESTIONS

The primary research question this thesis seeks to answer is:

- What challenges will be faced by the Services in implementing the CAIV concept on new systems?

The following subsidiary questions also will be addressed:

- What is the difference between CAIV and the DTC program required in the past to control and manage program costs?
- What advantage does the CAIV concept outlined in the updated DOD 5000 series documents offer the Services?
- What systems can be used as benchmarks for CAIV implementation?
- What issues will program managers face in implementing CAIV?
- What recommendations can be offered to program managers to best address problematic CAIV issues?

D. SCOPE AND LIMITATIONS

The concept of CAIV is one of considerable breadth. The CAIV Working Group identified the following steps that may be used to achieve CAIV objectives:

1) Set realistic but aggressive cost objectives early in each acquisition program
2) Manage risks to achieve cost, schedule, and performance objectives

3) Devise appropriate metrics for tracking progress in setting and achieving cost objectives

4) Motivate and incentivize government and industry managers to achieve program objectives

5) Put in place for fielded systems additional incentives to reduce operating and support costs [Ref. 5:p. 2]

This research focuses on the first step, the establishment of cost objectives, and the fourth step, motivating and incentivizing managers to achieve objectives. The other steps are considered beyond the scope of this thesis and are suggested as potential areas for further study.

In addition, the thesis will concentrate on CAIV as it applies to hardware acquisition and will not specifically address contracting for services. The thesis will reference existing CAIV implementation on current systems but will not attempt a detailed case analysis of any particular program.

E. METHODOLOGY

1. Overview

The following steps will be used to collect and analyze data:

- Identify past cost control programs
- Describe the DTC program
- Develop and analyze DTC cost control issues

- Examine the CAIV cost control initiative
- Identify commercial cost goal establishment procedures
- Develop interview questions
- Conduct interviews
- Identify implementation issues facing program managers
- Develop recommendations

2. Data Collection

The data collection effort uses two methods to obtain information: literature review and structured interviews.

The literature review will focus on identifying key elements of past cost control programs, and examining the CAIV concept. The data will be collected from a variety of sources including magazine and journal articles, books, the internet, briefings, reports, regulations, manuals, and conference proceedings. Case studies from past DTC programs also will be examined to develop issues and recommendations.

Interviews were conducted either in person or by telephone. Representatives from the Department of the Army, the Department of the Navy, and Project Offices will be contacted. Specific questions will be tailored to the backgrounds, of the individuals or organizations and will be identified in subsequent sections of the thesis. The interviews will be intended to supplement the literature review.

3. Data Analysis

The analysis of the data will focus on identifying similarities between the DTC program and CAIV, identifying issues that program managers will face implementing CAIV and developing recommendations to assist program managers in implementing CAIV.

F. ORGANIZATION OF STUDY

This thesis will consist of five chapters. The content of the remaining chapters is described below.

Chapter II -- DOD Cost Control Background -- A history of cost control initiatives and programs, and a description of the DTC program.

Chapter III -- Cost as an Independent Variable -- Analysis of the CAIV concept as outlined in DOD 5000 documents, studies prepared by the CAIV Working Group further defining CAIV, and upper management direction/policies regarding CAIV. Key elements of CAIV are described and compared to DTC.

Chapter IV -- Analysis of Data -- Data analysis to provide a comparison of DTC and CAIV. Issues will be identified that program managers face implementing CAIV.

Chapter V -- Conclusions and Recommendations -- A summary of the results of analyses in previous chapters, provision of answers to the research questions and recommendations for the Services to consider when implementing CAIV.

II. DOD COST CONTROL BACKGROUND

A. OVERVIEW

The need for cost control is a continuing issue facing the DOD. Over the past twenty-five years design-to-cost (DTC) was the primary cost control program that DOD implemented. The DTC program was revised many times. This chapter will focus on providing a history of DTC, and describing key elements of the DTC program.

B. HISTORY OF DTC

In one of the earliest statements mentioning a "design-to" cost control policy, Dr. John Foster, Jr., the Director of Defense Research and Engineering stated in March 1970:

> We shall insist relentlessly -- as a point without peer in our management -- that price has as much priority as performance....We must design-to-a-price, a much lower price, or else we will not be able to afford what we need. Defense budgets are going down. The costs of what we need are going up, just our essential needs, are going up. Our only solution is to make cost a principal design parameter. That is how we must now define what is "best". We have no other choice. [Ref. 6]

Dr. Foster is generally credited with establishing the "design-to" concept within DOD.

The problems facing the DOD in 1970 appear similar to problems facing DOD today. Weapon system costs were increasing and the budget was decreasing. Dr. Foster's policy was formally implemented the following year in the release of DOD Directive 5000.1.

The DOD Directive 5000.1 released on 13 July 1971 addressed cost in the following paragraph:

> Cost parameters shall be established which consider the cost of acquisition and ownership; discrete cost elements (e.g., unit production cost, operating and support cost) shall be translated into "design-to" requirements. System development shall be continuously evaluated against these requirements with the same rigor as that applied to technical requirements. Practical tradeoffs shall be made between system capability, cost and schedule. Traceability of estimates and costing factors, including those for economic escalation, shall be maintained. [Ref. 7]

This Directive officially established DTC as a new acquisition approach and required implementation within 90 days. The Services were left to develop their own policies regarding implementation, and an implementation guide was not published for over two years.

Early guidance specifically addressed both the cost of producing a system and the cost of operating and supporting the system. Ownership costs were known to represent a major portion a weapon systems costs.

On 16 August 1972, Dr. John Foster, Jr. addressed an Armed Forces Management Association/National Security Industrial Association Cost Symposium. Dr. Foster described the new policies established by DOD 5000.1. The key to successful implementation was to gain an understanding of the differences between the old acquisition concepts and the new concept. The following policies were implemented by the new DOD 5000.1 [Ref. 7]:

- Reducing concurrency
- Designing to cost requirements
- Using prototypes
- Requiring hardware competition
- Reducing radically the size of industry design teams
- Minimizing the number of detailed weapon system requirements
- Increasing independent OT&E prior to the procurement decision

A number of these policies placed an additional burden on research, development, test & evaluation (RDTE) funding. Prototypes, hardware competition and increased OT&E prior to the production decision required additional RDTE funds but were expected to result in net savings in the later phases of the program.

Dr. Foster's address also highlighted the DOD position on Cost and performance tradeoffs. He stated:

> We are willing to take the radical step of ordering into production a less capable piece of equipment -- compared one-for-one with an alternative system -- if we can get substantially greater numbers and therefore, increased total combat strength....Within our fiscal constraints, what is really best is the right combination of individual quality and sufficient numbers. And so our objective is the "best" in this broader context...not individually best. [Ref. 6:p. 3]

Dr. Foster's message was not usually put into practice. In most cases performance was still the most important criterion for development of a weapon system. Many systems attempted to obtain the last 10% gain in performance even if it meant substantially

raising the cost of the product. Rather than trade for higher quantities of a less capable weapon, quantities were reduced to produce fewer than the desired quantity. This factor is one of the issues discussed in detail in Chapter IV.

A number of other memorandums and briefings provided initial guidance in setting up the DTC program. Support contractors also prepared reports on the subject in response to DOD requests. The Services attempted to implement DTC but specific implementation procedures were lacking. Cost goals were established for major programs with different ground rules and assumptions.

The first official implementation guide, the Joint Design-to-Cost Guide was released on 3 October 1973 by the Departments of the Army, the Navy and the Air Force. Originally, Dr. Foster addressed the "design-to" concept using the word price rather than cost. The term price inferred total life cycle cost. The DOD 5000.1 also addressed both the production and the operating and support (O&S) costs. The new guide recognized the importance of O&S costs but placed emphasis on unit production costs. The official definition of design-to-cost included only production cost elements. The guide defined design-to-cost in the following manner:

> Design to Cost is a process utilizing unit cost goals as thresholds for managers and as design parameters for engineers. A single cumulative "average unit flyaway cost" goal is approved by [the] DSARC for the program. This goal is then broken down into unit production cost goals by the program manager and provided to each contractor or inhouse source for the appropriate major subsystem. [Ref. 9:p. 4]

The guide did address life cycle costs by stating that O&S costs should be included as part of the design-to requirements. However, the goal for both the government and contractor managers included only production costs. If the goal includes only production cost elements, then the emphasis will be on achieving the production cost goal, not on minimizing life cycle cost. Centering cost control efforts on the near term costs at the expense of O&S costs is discussed in Chapter IV.

Although the Joint DTC Guide was updated a number of times in the 1970's, the emphasis on production costs remained. Later versions did provide requirements and guidance in establishing cost goals for O&S cost drivers.

The DOD Directive for DTC was also released and updated. Two different versions of military standards (MIL STD) for DTC were developed for incorporation into contracts. Individual organizations within the Services also published guidance for use in implementing DTC.

A different definition of DTC is provided by Military Handbook (MIL HDBK) 766. This definition removes specific mention of the costs of different phases. However cost is defined as lifecycle cost. The MIL HDBK 766 defines DTC as:

> An acquisition management cost control technique established to achieve defense systems designs that meet stated cost requirements. Cost is a design requirement addressed on a continuing basis as part of a system's development process. The technique embodies early establishment of realistic but rigorous cost objectives, goals, or targets and a determined effort to achieve them. [Ref. 10:p. 7]

This is the definition of DTC that is used during the remainder of this thesis. The concept appears relatively simple: cost is considered as a design requirement, the same as performance. The actual implementation proved difficult and the DTC program ended with the cancellation of the military standard in 1995.

C. KEY ELEMENTS OF DTC

DOD relied on the DTC program to manage costs. Successful implementation of DTC required the Services be able to address a number of different questions. The following questions are discussed:

- How are DTC targets/goals developed?
- When are targets and goals implemented?
- How are goals incorporated into contracts?
- What incentives are used to motivate government and contractor management?
- How is the status of a DTC program monitored?
- What happens when a program is projected not to meet the cost goal?
- How does the DTC goal relate to the budget?
- What organizations are involved in the DTC process?

1. How Are Targets/Goals Developed?

Setting realistic cost ceilings was one of the elements of DTC implementation addressed by Dr. Foster during his speech at the cost symposium mentioned earlier.

There is very little guidance in the later documentation relating to the establishment of cost goals. Four approaches were presented for use in determining cost ceilings by Dr. Foster:

> 1) We could estimate the money available for a new system, divide by the estimated numbers needed, and thereby derive the total cost per copy. That is an important approach, but the techniques to do it well are not fully in hand.
>
> 2) We could relate the cost ceiling to the actual costs of related existing systems. For instance, we have put the lightweight fighter cost ceiling in between the cost of the F-5E International Fighter and the F-15 Fighter, since its performance goals fall in between those two. So we estimate what a required performance should cost and, if it appears low enough to provide adequate numbers, we can use that figure as the cost ceiling.
>
> 3) We could simply set the cost for the new system at the cost of the systems it is to replace. For instance, we could peg the Agile missile cost equal to that of the present Sidewinder. With this approach, the designers are challenged to use technology to get improved performance at a reduced cost; a downward cost pressure which matches the upward push of inflation. I strongly support the thesis that technology can be harnessed to reduce costs. Look at the size and cost of your transistor radio; it's less costly than the vacuum tube radios of 25 years ago -- in spite of inflation. As we push technology to reduce unit production costs and lifetime operating costs, research and development expenditures will have to rise, but over the long pull total defense expenditures will be better controlled.
>
> 4) Where it is impossible to find a formula for a realistic and logical cost ceiling for a new system, we will have to use judgment to pick a best figure and then iteratively adjust the figure as we start and test some designs. [Ref. 8:p. 4]

Setting cost goals is one of the most important steps in the process. These four approaches outlined methods to establish a cost goal. Each of the four approaches has some advantages and disadvantages.

The first approach requires the cost estimator to know with certainty the budgets that would be available in the future in order to develop a cost goal. It must be remembered, that the initial DTC policies covered not only production costs but O&S costs. Since the production and operation of the weapon system spanned many more years than available in the budget documentation, this approach was not feasible.

The second approach could be used but, does not achieve the full benefits of the DTC concept. One of the reasons for implementing DTC was to reduce the increasing costs of weapon systems. By setting cost goals based on these weapon systems, the target may be based on a system that was too costly. The old system was not subject to cost/performance tradeoffs during the development cycle. In this case, performance may end up being traded off for cost since performance is lower than for the previous system. In most cases, performance will be increased beyond the capabilities of the current system and no previous upper bound will exist.

The third approach may have the biggest impact on reducing costs by setting cost goals that require a change or improvement to the existing methods used to produce a system. The problem with this approach, discussed later, is that in most cases improved technology required additional costs, both for the hardware and the facilities to produce the hardware. The end result is that costs increased.

The fourth approach may be the best approach since early in concept development there are too many unknowns to place a point estimate on production

or life cycle cost. An iterative approach allows a contractor to develop a system that is in the "ball park" and then to set a specific target once technology and capabilities are known.

The issue of setting point estimates and setting cost goals early in a development program for high technology programs is also discussed in Chapter IV. Cost goals are based on the entire projected buy and on the quantity profile in place at the moment.

2. When Are Targets/Goals Implemented?

Cost goals are required as part of the milestone process. Every new system must establish a cost goal as part of the requirements definition process. During the concept exploration phase, major configuration decisions are made to define the program. Costs are determined for the various alternative design approaches. At this stage of program development the cost goal may be specified as a range rather than a point estimate. It is well known that design and configuration decisions made early in the program generally influence cost to a greater extent than decisions made later in the program. [Ref.11] Figure 2.1 shows the relationship between the stage of development of a system and the percent of life cycle cost that has already been committed due to design decisions.

Early in the program, the least amount of information is available to use as a basis for design decisions, yet the impact on overall cost is the greatest. The

importance of early emphasis on cost control in the decision process is discussed further in Chapter IV.

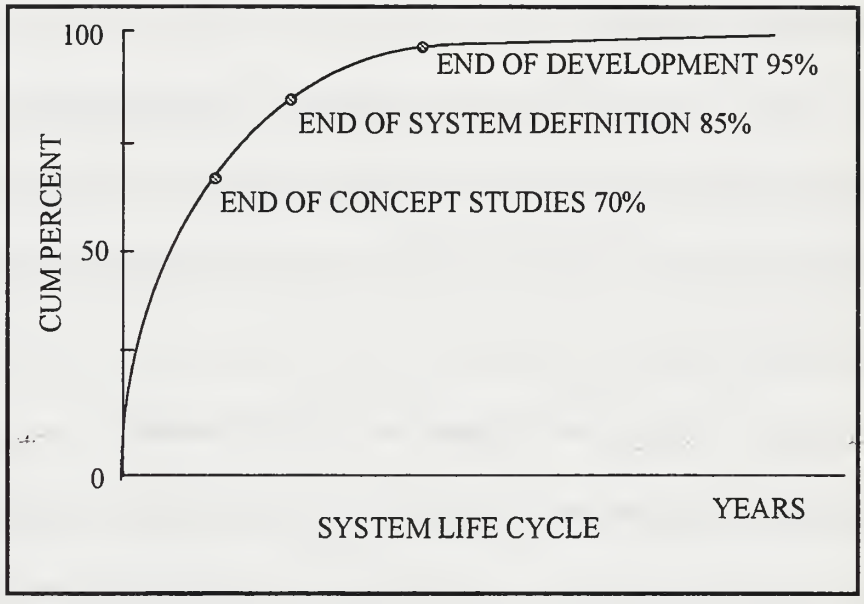

Figure 2.1 Schedule of Decisions Affecting LCC [Ref. 11:p. 31]

Cost goals are updated at each milestone until a firm system goal can be established prior to the milestone II review. At this point, the decision process usually selects a concept from a number of alternatives. Each concept will have different performance and cost characteristics. The importance of this selection is highlighted in Figure 2.1 showing that over 85% of the life cycle costs are committed by this milestone decision.

During the engineering and manufacturing development (EMD) phase, the production unit cost goal is stated as a point estimate based on procuring a fixed quantity of hardware over a given time period. The goal usually includes the entire quantity that is expected to be procured. The goal should be stated to ensure that both

government and contractor can easily understand the elements included. Cost goals for O&S cost drivers are also specified at this time.

3. How Are Goals Incorporated Into Contracts?

The program manager must, "define design to cost targets in terms which are auditable, contractually enforceable, and meaningful to both contractor and government." [Ref. 9:p. 40]. Cost goals can be specified by the government in the Request for Proposal (RFP) or can be proposed by the contractor during the bid process.

In the concept exploration phase, often goals or targets are specified but are not included as part of the contract. There are too many unknowns at this point to make a cost goal contractually binding. This phase should generate sufficient data to allow a goal to be developed for the next phase.

The program definition and risk reduction (PDRR) phase should contractually include a design to cost target, along with acceptable performance levels and a projected schedule. The RFP also must state the relative importance of the various design factors for source selection purposes. The importance placed on the current contract cost and the projected production unit cost goals during the proposal evaluation process is discussed in Chapter IV. Along with the cost target, the contract should specify the management plan, cost drivers, trade studies, cost elements/factors,

reporting requirements, data requirements, minimum essential performance requirements and planned cost reviews. [Ref. 9:p. 38]

The EMD phase should include the items specified above and also include cost targets for O&S cost elements. The question of how to emphasize O&S cost goals in contracts also is discussed further in later chapters.

The contractor should address the following areas to be evaluated by government personnel during the source selection process when responding to an RFP:

Design balance - The contractor must describe how they will balance the program's performance requirements, cost, production rates, supportability elements and schedule.

Cost databases/models - The contractor must provide supporting rational for cost estimates.

Flexible requirements - The contractor must provide recommendations to government on how to structure requirements to encourage technological innovations, and present opportunities for trades. In addition, the contractor should identify nonessential specifications and requirements.

Risk - The contractor must identify high risk areas that may impact cost.

Ranking - The contractor should rank the program's design parameters for the purpose evaluating tradeoffs.

Trade studies - The contractor should conduct trade studies on the top ten cost drivers and provide alternative solutions.

Compatibility - The contractor should provide data to assure the compatibility of the proposed system, equipment and facilities.

Latitude - The amount of latitude provided the contractor is influenced by the degree of risk, performance requirements and schedule. The contractor should recommend the degree of latitude they require and provide justification to support the recommended level.

DTC requirement factors - The contractor must identify the impact quantities, rates, time periods, award/incentive fees and the deployment concept have on the cost goal. [Ref. 10:p. 36]

4. What Incentives Are Used To Motivate Managers?

Two main types of incentives can be used to motivate contractors to achieve cost goals. The greatest incentive appears to be the use of competition in the development process. [Ref. 10:p. 32] Although carrying two or more contractors through all the phases of development substantially increases RDT&E costs, the expected savings in production and O&S dollars should produce a lower life cycle cost. When competition is maintained throughout the development program, other DTC incentives may not prove effective. The amount of future business that may be

impacted by competition is far greater than the amount of revenue that can be gained from a monetary incentive.

An award fee is usually established as part of the EMD contract. The award is based on the ability of the contractor to achieve production unit cost goals and/or O&S cost goals. The fee is paid only after achievement of the goal is actually demonstrated, and it is usually paid a number of years after the completion of FSD. The amount of the fee is limited to 15% of the amount of the development contract. Higher fees can be specified by requesting a waiver to policy. A fee of 3% to 12% of the development contract is the normal range. [Ref. 10:p. 33]

Government managers have powerful incentives to achieve or exceed cost goals. The threat of program cancellation is one of the biggest incentives for government managers. Chapter IV will discuss some of the problems encountered by government managers in establishing and managing to achieve cost goals.

5. How Is Program Status Monitored?

Cost goals are specified in government program management documentation forwarded to higher headquarters. Among the documents that contain cost goals are the acquisition program baseline (APB) document, selected acquisition report (SAR), and the decision coordinating paper (DCP). Contractor progress is monitored by periodic progress reviews, review of specific reports, and data specified in the contract.

6. What Happens When A Program Cannot Achieve A Cost Goal?

The contractor should continually make tradeoffs to ensure that the cost goal is attained. After exhausting tradeoff possibilities, if the contractor still cannot achieve the goal, the government has two choices. The government can either terminate the program or continue the program realizing that production and/or O&S costs will be higher than anticipated. Contractor cost goals are generally not increased unless the cost increase is caused by the addition of requirements or other government initiated fluctuations to the baseline. The entire subject area relating to the failure to achieve cost goals will be discussed in chapter 4.

7. How Does The Cost Goal Relate To The Budget?

There are no specific instructions for program managers to relate the contractual DTC goals to their budgets. In the early stages of development of the DTC concept the intent was for the DTC goal to represent the contractor's portion of the production costs and was directly related to the budget. [Ref. 8:p. 2] The failure over the years of the contract to achieve DTC goals has led government managers to include significant risk funding above the level required if the DTC goal was realized.

The DTC goal is calculated based on the entire projected buy. At the time of establishment of the DTC goal, the total quantities and the yearly quantities used to calculate the goal match the budgeted quantities. Since budgets fluctuate almost every year, the yearly quantity assumptions used to calculate the DTC goal usually do not

match the budget at the end of a particular phase of a program. The DTC goal specified in the contract is not updated every time the budget changes but, the contractor should provide sufficient data to allow a projection to be made to update the original goal using the new budget and quantity assumptions.

8. What Organizations Are Involved In The DTC Process?

The DTC process involves program managers, contractor personnel, the user, cost group personnel and contracting personnel.

The user is involved early in the process during the concept formulation. However, once a program manager is selected, usually by the time a program reaches milestone I, user involvement is over. [Ref. 9:p. 22] The user may become involved at a later point if the contractor projects a significant overrun to the goal. At this point the program is reviewed by higher headquarters for continuation and the user might be requested to lower requirements. In practice, the user remains involved throughout the development and production phases. However, the focus of the involvement is not on the cost/performance tradeoff process.

The government program manager must monitor the contractor DTC program, report progress to higher headquarters, and approve and/or recommend tradeoffs between cost, schedule and performance. The contractor implements the DTC program according to the contract and the specific management plan. The local command provides contracting and cost analysis for implementation and review of the

DTC program. Higher headquarters personnel review government program manager and contractor reports and also may require government program reviews that analyze DTC progress.

D. SUMMARY

Key aspects of the DTC implementation process were analyzed for comparison to the current cost control policy. The DTC program evolved over a 25 year implementation period. However, the overall results anticipated were not achieved. Chapter IV will analyze in detail some of the issues introduced in this chapter. Areas considered key to understanding the DTC concept are the goal setting process, cost goal/target tracking, cost elements, incentives, relationship to the budget, contractual factors, and characteristics and responsibilities of organizations.

III. COST AS AN INDEPENDENT VARIABLE

A. OVERVIEW

As part of the reform process the Department of Defense 5000 series documents have been updated. There are two new documents, one containing mandatory rules, DOD 5000.2-R and the other, DOD 5000.1, containing general guidelines. Fewer mandatory requirements are specified in the new DOD 5000.1 than in the previous DOD 5000 series documents. In theory, this allows managers more flexibility to manage programs.

Six major themes are blended throughout the updated 5000 series documents. These themes are:

- Teamwork
- Tailoring
- Empowerment
- Cost as an Independent Variable
- Commercial Products
- Best Practices

The themes are blended into the documents but are not clearly defined in a manner that makes them usable to most program managers or contract officers. The new DOD documents present the theme but leave implementation issues to individual offices and

programs. Further information on some of the themes may be obtained from DOD sponsored working groups but, little has been published to date on the Cost as an Independent Variable (CAIV) concept. Most published information is not as specific as the implementation information contained in older DOD documents.

This chapter will focus on one of the major themes, CAIV. The history and key elements of CAIV will be discussed.

B. HISTORY OF CAIV

In a 19 July 1995 Memorandum to all the Military Departments, "Policy on Cost-Performance Trade-offs," the Under Secretary of Defense for Acquisition and Technology, Paul Kaminski introduced the concept of CAIV to the DOD community. In the memorandum he stated:

> I am committed to establishing a process whereby cost is an independent variable in programmatic decisions, and cost goals are set in each phase. I believe this process will allow us to provide the most performance for an affordable cost. The overall result will be to increase the effectiveness of our forces while remaining within the bounds of our resources. [Ref. 12:p. 1]

Implementation of the policy was made mandatory for all ACAT ID programs and encouraged for all other programs. Each Service was requested to designate two ACAT ID programs to serve as demonstration programs and to provide feedback showing the effectiveness of the CAIV approach to acquisition. [Ref. 12:p. 1]

The new DOD 5000.2-R requires that CAIV be addressed in all program acquisition strategy. The CAIV process is specified in Part 3, paragraph 3.3.3 as follows:

> The acquisition strategy shall address methodologies to acquire and operate affordable DOD systems by setting aggressive, achievable cost objectives and managing achievement of these objectives. Cost objectives shall be set to balance mission needs with projected outyear resources, taking into account anticipated process improvements in both DOD and defense industries. [Ref. 13,Part 3:p. 6]

Subparagraphs discuss cost/performance tradeoffs and cost management incentives.

Cost/performance tradeoffs are conducted prior to the finalization of an acquisition strategy. Tradeoffs on programs designated ACAT I shall involve a cost/performance integrated product team (CPIPT) and include user representation. The tradeoffs should result in the establishment of a life cycle cost objective at Milestone I. The flexibility given to the project manager and contractor to perform cost/performance tradeoffs is considered essential to achieving cost objectives. This factor is highlighted by the following direction provided by DOD 5000-2.R:

> ...the number of threshold items in requirements documents and acquisition program baselines shall be strictly limited, the threshold values shall represent true minimums, and requirements shall be stated in terms of capabilities, rather than technical solutions and specifications. [Request for proposals] RFPs shall include a strict minimum number of critical performance criteria that will allow industry maximum flexibility to meet overall program objectives. [Ref. 13, Part 3:p. 7]

The trade-offs between schedule, performance and cost are key elements of the CAIV process. Cost is defined as total life cycle cost. Unlike previous cost control programs, schedule and performance are now considered functions of cost. Previously performance was usually the critical design criterion and cost became an outcome or result of the design. [Ref. 14:p. 3]

A few of memoranda and the new DOD 5000 series documents provided the early guidance describing the implementation CAIV process. A CAIV Working Group formed by Kaminski prepared an Implementation Guidance paper. The paper focused on what needs to be done and not on how to do it. For example, the guidance states, "ensure that RFPs and contracts require contractors to develop and implement a management approach for achieving cost objectives." [Ref. 15:p. 1] The problem today, as with past cost control programs is how to answer the "how to" implementation questions. From the paper emerged the general ideas of CAIV. However, a specific definition and implementation guidelines for program managers were left out.

During the same time period, the CAIV Working Group also prepared additional guidance that outlined the CAIV approach to weapon systems acquisition. The steps the CAIV Working Group outlined to achieve CAIV objectives were listed in Chapter I. The steps in the process include:

- Setting realistic but aggressive cost objectives early in the acquisition program

- Managing risks to achieve cost, schedule and performance objectives
- Devising appropriate metrics for tracking progress in setting and achieving cost objectives
- Motivating government and industry managers to achieve program objectives
- Putting in place for fielded systems additional incentives to reduce operating and support costs

[Ref. 5]

The CAIV Working Group guidance relating to risk management and metrics are discussed later in this section. The thesis focuses on the other areas.

The CAIV Working Group guidance provides answers to some of the CAIV "how to" type questions. The paper also describes the activities of the CPIPT. The CAIV Working Group paper describes three main activities performed by the CPIPT. [Ref. 5]

The first activity that involves the CPIPT is the cost/performance tradeoff process. The cost and operational effectiveness analysis (COEA) is used to perform the cost/performance tradeoffs. In the past, the COEA was used to perform tradeoffs at the system level and sometimes at component levels if different technologies were present. Using the COEA to perform design tradeoffs that can actually model impacts of all the operational requirements document (ORD) or baseline performance and operational characteristics at component levels will require an expansion of the capabilities of the existing COEA software models.

The CPIPT also assists in setting program cost goals. Currently, program offices prepare an acquisition program baseline (APB) that contains cost goals and thresholds for the development and procurement phases of a program. At least for major programs, OSD already assists in setting these goals. The major programs are approved by OSD during milestone reviews and the approved cost profile usually becomes the program APB cost goal. The CPIPT involves OSD earlier in the establishment of the goal. This is intended to save time during the milestone review process if the cost profiles are already agreed to by an empowered OSD CAIG representative.

The third activity of the CPIPT is to recommend and approve design and engineering changes that do not impact required performance. This is an activity that the project manager is already chartered to perform. Design changes are frequently made in both development and production programs. The project manager usually works directly with the user to enact these changes. The CPIPT is supposed to focus on design changes to reduce development, procurement and support costs.

The CAIV working group outlined a risk management approach. The working group stated that contractor use of mature processes should be a significant factor in source selections. Many times source selections choose the contractor that proposes the greatest technological breakthrough, vice the one proposing the least risk. The working group prepared a table of factors and indicators that can be used to determine

progress in managing risks. The ability of a program to demonstrate the factors, is intended to help measure the amount of risk in a program. By examining these factors, a program manager can better decide where cost/performance tradeoffs are necessary. Table 3.1 lists the factors and indicators proposed by the working group:

FACTOR	INDICATOR
- Design Simplification	- Mission simulation complete - 80% solution analysis complete
- Mature Manufacturing Processes	- Scaleable process demonstrated
- Technology	- Product available - Market prices established
- Effective Integration	-100% 3-D product model exists - Test articles available - Software available
- Commercial Processes and Components	- Environmental suitability established
- DOD Prototype	- Integration verified
- Elimination of Unecessary DOD Unique Business Practices	- Low cost business processes employed

Table 3.1 Risk Factors and Indicators [Ref. 5]

In the past, risk management was a part of the weapon system acquisition process. However, it focused on managing technical or performance risk. Cost risk management must now take on equal or greater importance than technical risk management. Cost/performance tradeoffs must be continually performed throughout the acquisition process and not just used to support milestone decisions.

The Working Group outlined metrics and observables that Program Managers can use to monitor and assess CAIV progress. The suggested metrics and observables are listed in Table 3.2.

METRICS	OBSERVABLES
- Are cost objectives defined and consistent with requirements and fiscal resources?	- Outyear resources identified? - Production and O&S cost objectives in RFP? - Key tradeoff issues addressed?
- Is DOD managing to achieve cost objectives?	- RFP contains minimum number of performance specifications? - CPIPT functioning? - Tradeoff space identified? - Risk plan? - Incentives in RFP and contract? - Mechanisms for contractor cost savings suggestions? - Cost objectives allocated to IPTs and suppliers? - Reliability and maintainability estimated/measured? - Robust contractor incentives plan in place?
- Are contractors managing to achieve cost objectives?	- Tools for tradeoffs provided? - Contractor participation in tradeoff process? - New technologies/mfg processes identified/implemented to reduce costs? - Procedural impediments to cost reduction identified? - Strong vendor relationship established? - Sound vendor incentive structure?

Table 3.2 Monitoring and Assessing Progress [Ref. 5]

The CAIV guidance is still evolving as implementation of the concept becomes more widespread. The CAIV approach to acquisition management is expected to result in less costly products and systems with lower life cycle costs, shorter program production, clearer and more innovative acquisition approaches and high quality products that fully meet true requirements. [Ref. 14:p. 4]

C. KEY ELEMENTS OF CAIV

To allow for comparisons to the DTC cost control program, the same questions listed in chapter 2 are applied to the CAIV concept. The following questions will be discussed in this section:

- How are CAIV targets/goals developed?
- When are targets and goals implemented?
- How are goals incorporated into contracts?
- What incentives are used to motivate government and contractor management?
- How is the status of a CAIV program monitored?
- What happens when a program is projected not to meet the cost goal?
- How does the CAIV goal relate to the budget?
- What organizations are involved in the CAIV process?

1. How Are CAIV Targets/Goals Developed?

The first step in the CAIV implementation process is to set aggressive cost objectives. Whenever aggressive cost objectives are mentioned, a sentence usually follows stating that these objectives will be much lower than previous cost goals for a system. Historically, most major programs have experienced overruns in development contracts and now the new cost goal is expected to be lower. In CAIV, cost refers to

total lifecycle cost. A higher development cost may be required to obtain a lower lifecycle cost. The cost goal must include both production and O&S cost elements.

A basic premise of CAIV is that the new cost objectives will be set using cost/performance tradeoffs. In the past, the threat was viewed as ever increasing and systems were developed based on defeating a projected threat 5-10 years into the future. For example, a warhead was designed to penetrate a number of inches of steel plate that was much greater than required for existing enemy systems only because it was projected that there might be a need in the future. Designing a system to meet a higher performance requirement usually involves more risk than designing a system to meet a lower requirement. The new CAIV tradeoff process will evaluate risk areas in advance and not try to attain performance requiring high risk developments if the performance is not required.

The CAIV approach to systems acquisition is described as a "business-like" approach. [Ref. 1] Industry relies on a market driven price to remain competitive. The automobile industry and consumer electronics industries are examples where the market ultimately determines the price that manufacturers can charge for products. [Ref. 14:p. 8] One market driven approach to setting cost goals is sometimes referred to as target costing. The target costing concept is defined as follows:

> ...a structured approach to determining the cost at which a proposed product with specified functionality and quality must be produced. Target costing differs from the...cost plus approaches found in many firms in that the desired cost to manufacture is specified. In practice, target costing appears to lead to products with lower costs than cost

> plus approaches. The most likely explanation for this is that designing to a specified low cost appears to create more intense pressure to reduce cost than designing to an unspecified low minimum low cost. This explanation is in keeping with research on goal setting, which finds that better performance emerges from setting specific, challenging goals. [Ref. 16:p. 34-35]

"Target costing is a tool for aiding decisions about design specifications and production techniques." [Ref.17:p. 18] Target costing relies on early design tradeoffs to ensure that a product can be manufactured for a given cost. The overall target cost is factored into lower level targets. Designers must achieve the lower level targets through the tradeoff process. Various studies have highlighted the fact that the majority of a product's production and support costs are already determined early in the design phase. Estimates range from 70% to 95%. [Ref. 18, Ref. 19]

The target costing approach still does not fully explain to a government program manager how cost goals or targets are set. The government is usually the only customer, or at least the first customer, for most weapon systems. There is no real market similar to the commercial sector to use as a basis to establish a realistic target cost. A system may receive a specific unit cost goal from a higher headquarters authority or could develop its own goal. The DOD Guide to IPPD lists a technique that is used by industry to perform cost/performance tradeoffs, and this could be used to assist in establishing the original goal for the government. The IPPD Guide describes quality function deployment (QFD) as:

> a systematic process for truly understanding the user's requirements and expectations and documenting the best approach and methods

> for satisfying these requirements. The customer at times states requirements vaguely, and at other times too tightly, i.e. a specific solution. The QFD process revolves around understanding what the customer really expects and focuses efforts on satisfying these needs through extensive trade-off analyses. QFD also provides a way of tracking and tracing trade-offs through various levels from requirements through design decisions to production and support phases. [Ref. 20:p. 2-5]

Bill Benzur, a QFD expert and quality management consultant, summarizes the promise of QFD by stating, "QFD has proven incredibly useful as a tool for bringing customer requirements into the engineering process." [Ref. 21]

The QFD technique relies on a "house of quality" (HOQ) to graphically depict the various combinations of user requirements and technical responses. Figure 3.1 depicts a simple HOQ structure.

The "wants" represent the customer needs and benefits referred to as the Voice of the Customer. Customer needs are not technical solutions to a problem. The needs represent the benefit the customer requires from a solution. Examples of customer needs include: light weight (e.g., under 50 pounds), 2000 meter range, meeting the performance requirement, production cost under $50,000 per unit, minimizing O&S cost, and a development schedule under 48 months.

The planning matrix includes information relating to the customer needs and benefits. The different columns could represent importance of the "want" or desire to the customer, how well the current system meets the need, how well the alternatives meet the need, or importance of meeting the need to the team. The

planning matrix should be completed as soon as possible to enable the technical team to place emphasis on the higher priority customer needs. [Ref. 22:p. 71]

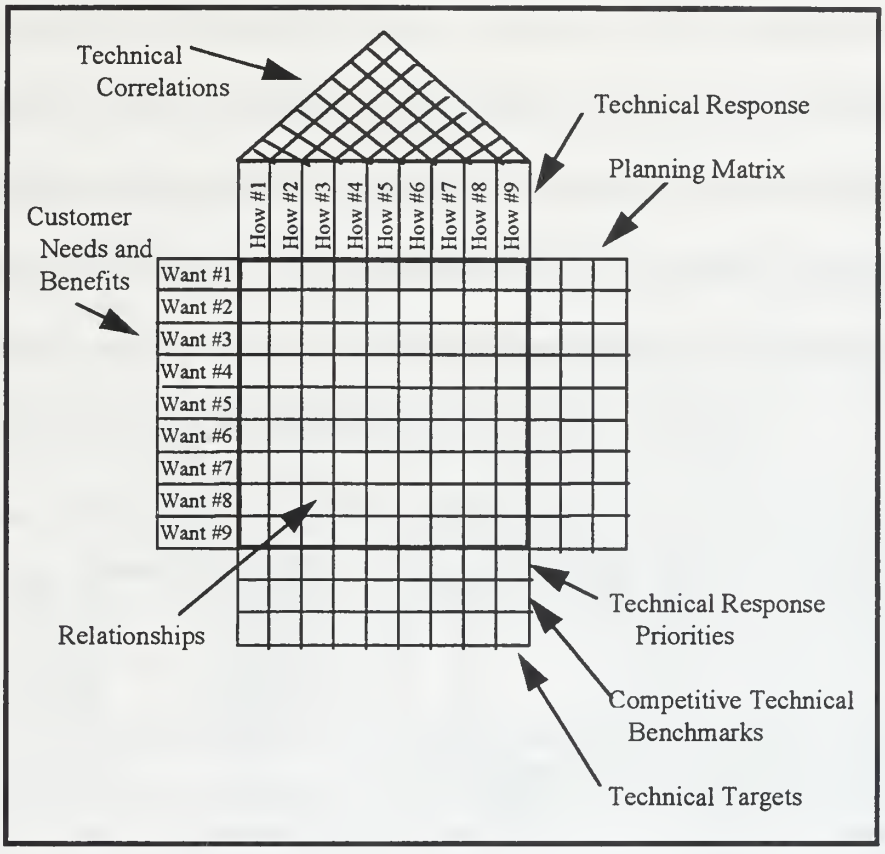

Figure 3.1 House of Quality Structure [Ref. 22]

The "hows" represent the technical responses, i.e., the Voice of the Developer. The responses can take a number of forms including metrics, product features of services, product requirements, etc. [Ref. 22:p. 72]

The relationships are represented by numerical values or descriptive terms. A set of descriptive terms that could be used include: no relationship, slight, moderate and strong relationship. If a column includes only weak relationships to all the rows, the item or feature could be eliminated.

The same techniques can be carried to lower and lower levels until the processes and production operations are uncovered. Figure 3.2 shows the flow down from one HOQ to the next level. As indicated in the figure, the "hows" from the top level HOQ become the "wants" on the next level. The classical model for QFD is shown in Table 3.3. This model allows the technical developer to establish priorities at the different levels of the development process. As shown in the table, the "how" from one level becomes the "want" for the next level.

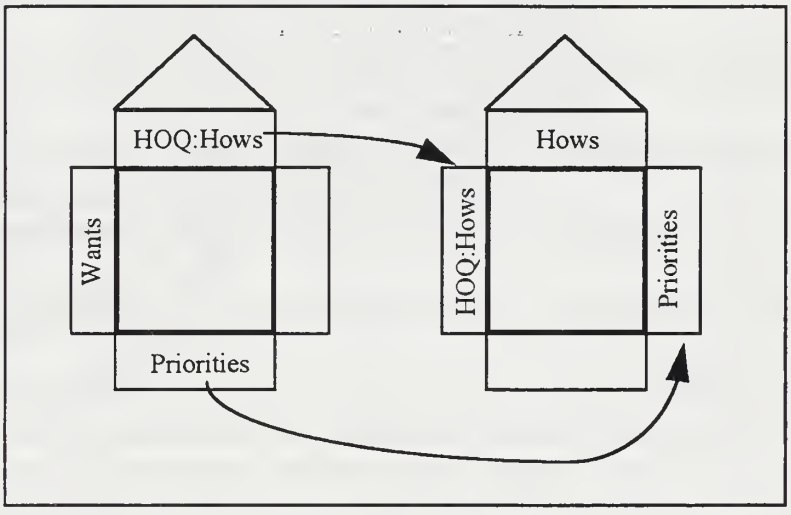

Figure 3.2 Flowdown Between Interrelated Matrices [Ref. 22:p. 14]

MATRIX	WANT	HOW
House of Quality	Voice of the Customer	Technical Performance Parameters
Subsystem Design Matrix	Technical Performance Measures	Piece-Part Characteristics
Piece Part Design Matrix	Piece-Part Characteristics	Process Parameters
Process Design Matrix	Process Parameters	Production Operations

Table 3.3 Classical Model for Quality Function Deployment [Ref. 22,p. 15]

A key step in the acquisition process is the translating of requirements into design and cost elements. The QFD approach allows the CPIPT visibility into the

details of the design required to estimate costs. Cost estimates can be generated for different requirements and designs. The user can then see the price to pay for a product or system. It appears that target costing and QFD could be integrated to provide a solid "business-like" approach to setting a DOD cost goal. Target costing would assign costs to the different design parameters and QFD would assign value to the design parameters based on the importance the user places on the parameter. Integrating the two techniques would identify components or features of a system that are costly and provide little benefit to the user. [Ref. 17:p. 18]

One technique used by industry to accurately cost products is activity based costing (ABC). The DOD Guide to IPPD also describes ABC as a valuable technique for cost analysis. The guide states that:

> ABC focuses on the activities [e.g., initiating purchase orders, machine set-up, machine labor hours, etc.] performed in the realization of a product. Costs are traced from activities to products, based on each product's consumption of such activities. The cost of a product equals the sum of all activities performed including overheads, capital costs, etc. [Ref. 20:p. 2-6]

The ABC technique provides the cost estimator an advantage in accuracy not available from other techniques. Cost estimates based on ABC will accurately cost systems and subcomponents. The cost/performance tradeoff process described earlier relies on accurate cost estimates to ensure that the most cost effective solution to a problem is developed. Depending on level of implementation, the QFD approach can provide visibility into contractor subcomponents, processes and production steps or operations.

The normal accounting procedures that defense contractors use to develop bids and report costs can lead to inaccuarate representations of an individual product or component cost. The normal accounting procedure is described as follows:

> It is not unusual for traditional manufacturing organizations to use a plant-wide or departmental rate to allocate the overhead costs to products. These organizations collect the indirect manufacturing costs incurred in a plant into a common pool and then allocate the cost to products on the basis of direct labor hours. Although product cost computed on such allocation fulfils the needs of external financial reporting, it is unsatisfactory for making product-related decisions such as product pricing...where accurate cost of individual products is important....The traditional overhead apportionment rates are too broad because they apportion overhead based on production volume even when production is driven by variables other than volume. [Ref. 23]

Figure 3.3 depicts the differences between the two approaches and is used to present a simple example illustrating the potential estimating inaccuracies inherent in the traditional method.

For purposes of illustration, assume that the Army is purchasing 300 new heavy trucks. One of the user representatives decides that because 30 trucks will be located in an area with three to four months of ice and snow, these vehicles should have an extra set of studded snow tires. The contractor proposal states that the additional cost per tire is only five dollars. The additional cost includes only the cost of the studs plus applicable overhead. The actual cost under the ABC method would include the costs of activities that resulted from the addition of the studded tires. Examples of such activities include the extra purchase order that a contractor would have to generate and

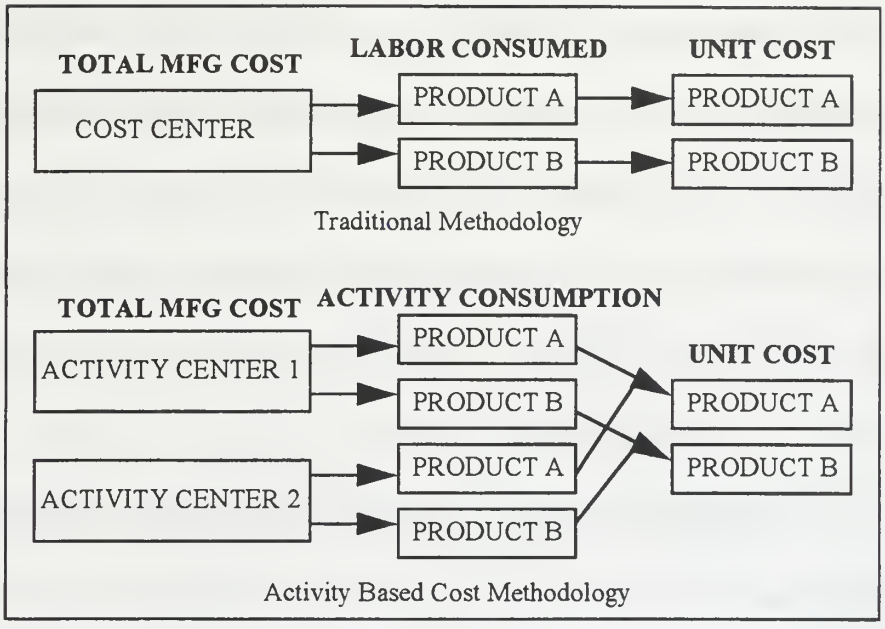

Figure 3.3 Comparison of Cost Accumulation Methodologies [Ref. 24]

possibly, the extra time to set up the line to produce studded tires. An additional setup cost of $5,000 is insignificant in terms of the total overhead collected into a cost center pool of the company. However, if the $5,000 is added to the order of 120 tires that actually caused the increase, it becomes significant. If the $5,000 is prorated over the 120 tires, the extra cost per tire for set up alone is over $40. Rather than adding only five dollars to the cost for the purchase of studs, the purchase of the studded snow tire actually increases both the overhead costs and the direct costs. It is obvious from the above example that additional alternatives should be investigated before purchasing studded snow tires. Perhaps tire chains would be an acceptable substitute.

Since overhead costs are usually allocated by charging a fixed rate based on usage of labor hours or material hours, the higher volume product will absorb the bulk of the costs. The addition of a new product or a special customized component may not cause a visible increase in overhead rates. By using ABC, a CPIPT comprised of both government and contractor personnel can estimate the true cost of components and "nice to have" features. The QFD process isolates the components and features that can be costed using ABC.

In addition to accurately estimating product costs, ABC can identify activities that can be:

> Reduced - reducing the time and effort needed to perform tasks by using efficient procedures (e.g., replacing an expensive labor operation with automation)
>
> Eliminated - eliminating non-value added tasks by altering design and procurement practices (e.g., reducing uneeded material handling operations)
>
> Shared - reducing the time and cost it takes to design and produce a product (e.g., by using existing parts and standardizing components rather than creating new ones) [Ref. 25:p. 25]

The previous section has introduced some of the techniques that businesses use to establish cost goals. These techniques can assist in developing a bottom-up estimate and to increase the user participation in determining the cost goals. During the earlier phases of the program, the goal may be specified as a range estimate, with the range narrowing at future milestone reviews.

The government can obtain a cost goal by development of a bottom-up estimate as described above. Alternatively, a cost goal may be directed by higher authority. A directed goal may result in the problem of a program facing an unrealistic goal. This issue is discussed in Chapter IV. However, the techniques described in this section will allow the government to determine the capability to be acquired for a directed cost goal.

2. When Are Targets And Goals Implemented?

The DOD 5000.2-R specifies that goals are established at Milestone I. The goals are also presented at the subsequent milestone reviews and can be adjusted and updated.

3. How Are Goals Incorporated Into Contracts?

The government provides cost goals in the RFP for both the production phase and the O&S phase. After a contract is awarded, contractors, subcontractors and vendors can become a part of the cost team and play an active role in cost/performance tradeoffs. The role of the various cost team members is discussed.

Unlike the previous cost control program, DTC, which could reference a military standard, CAIV does not have an applicable document to serve as a reference. There is no structured or formal reporting system is required of the contractor. Each Program Office must specify appropriate feedback mechanisms to allow sufficient monitoring of contractor progress.

4. What Incentives Are Used To Motivate Government And Contractor Management?

Competition is still considered the primary incentive to motivate industry to design and manage programs to achieve cost objectives. The government must maintain competition to the extent possible in the development cycle, and also must have a mechanism to restart competition in production if necessary. The contractor should compete and incentivize subcontractors. [Ref. 5]

Source selections must emphasize not only production costs but O&S costs in the evaluation process. In addition to competition, award or incentive fees and sharing of cost savings should be incorporated into the contract. [Ref. 5] Various incentives are discussed in Chapter IV.

Competition within the government also is mentioned as a technique to incentivize both government and contractor managers. The CAIV Working Group stated that acquisition programs within the same mission area could compete for funds. [Ref. 5] This type of competition is discussed further in Chapter IV.

The government and contractor program managers always face the possibility of program cancellation if a cost goal can't be achieved. Incentives will be discussed further in Chapter IV.

5. How Is The Status Of A CAIV Program Monitored?

The CPIPT is a continually functioning team and should include contractor personnel. The team should monitor the progress toward achieving the goal and

evaluate trade-offs that will allow realization of the goal. Programs still face the normal milestone reviews where cost goals are presented and discussed.

6. What Happens When A Program Is Projected Not To Meet The Cost Goal?

The government and contractor team must examine the cost/performance tradeoffs available that may help lower the projected costs. If system performance is above the minimum required performance and tradeoffs are available, the project manager can authorize a design change. If there are no potential tradeoffs that allow achievement of the minimum requirement, the government has two choices: (1) raise the target cost, or (2) cancel the program. Either of these choices requires a higher level headquarters review. [Ref. 14:p. 6]

7. How Does The CAIV Goal Relate To The Budget?

There is no specific guidance relating the CAIV cost goal to the budget. The only guidance states that the program costs should be budgeted. Government cost estimates incorporating a cost goal usually include additional risk funding. During the early phases of a program, the goal is stated as a range, not a point estimate and some uncertainty is expected. This area is discussed further in chapter 4.

8. What Organizations Are Involved In The CAIV Process?

The CPIPT is the main group involved in the CAIV process. An attachment to the Kaminski Cost Performance policy letter describes the activities of the CPIPT and lists the organizations that are represented on the team.

The CPIPT is led by the project office representative. In addition to technical, cost, logistics and contracting personnel from within the project office or local command, the user, the Army and OSD staff are supposed to play a greater role in the costing process than in the past. Representatives from both OSD Program, Evaluation & Analysis (PA&E) (the organization that studies affordability issues and uses the COEA) and the OSD CAIG are permanent members of the CPIPT. In addition, the Army also will have PA&E and cost analysis representatives. This results in a rather large group that is expected to be empowered to make decisions regarding project costs. The CPIPT will be more active during the milestone review cycles.

A smaller team within the program office is to be established to work CAIV issues on a daily basis. Different functional elements from within the program office, the user, the contractor and other functional organizations within the command are represented.

D) SUMMARY

Key aspects of CAIV were analyzed for comparison to the DTC cost control policy. The CAIV concept is similar to DTC. However, differences exist in concept and implementation that may allow programs managing costs under CAIV to succeed in realizing cost control goals. Areas considered key to understanding the CAIV concept are the goal setting process, incentives, contractual factors and characteristics and responsibilities of organizations.

IV. ANALYSIS OF DATA

A. OVERVIEW

Previous chapters defined the DTC and CAIV processes. The DTC and CAIV concepts are very much alike. Like CAIV, the DTC concept is based on a "business-like" approach. This approach is described in the following paragraph:

> In the design, development, production and marketing of its own commercially sold products, American industry has continuously demonstrated a great capability to achieve new product designs which reflect a highly sensitive balance between design, production costs, and market potential. The Government is hoping to benefit from this capability by emphasizing its use in weapon system development. [Ref. 26, Pg.4]

The above paragraph is from a 1972 report by the Research and Engineering Advisory Committee (REAC) of the National Security Industrial Association (NSIA). The original DTC concept also attempted to leverage from successful industry practices. The DTC program was canceled due to the overall ineffectiveness of the program. There were some success stories so maybe the problem was not with the DTC concept but with the implementation of the concept.

It would appear that programs implementing the CAIV concept may face the same types of problems past programs encountered implementing DTC. This is true for some areas; however, industry approaches to cost control and goal setting have changed as described in the previous chapter.

This chapter will compare DTC and CAIV, describing similarities and differences. There are key differences between DTC and CAIV, in both conceptualization and implementation. Issues will be developed that must be addressed for successful CAIV implementation. Problems that programs have encountered during DTC implementation formed the basis for development of the issues presented in this chapter. Issues are grouped into subject areas.

B. COMPARISON OF DTC AND CAIV

The key elements of DTC and CAIV are compared based on the eight areas discussed in Chapters II and III.

1. How Are Targets/Goals Established?

The development of a goal in the CAIV process is similar to the development of a goal in the DTC process. Goals can be directed by higher headquarters or estimated using cost analysis techniques. Bottoms-up engineering estimates are the most common form of process for setting cost goals.

The DTC Joint Implementation Guide described the team approach to goal setting. The team was formed prior to milestone I. Later, when a Project Manager was assigned, the team usually was disbanded. The team performed the tradeoff analyses. A big difference in the tradeoff process under DTC is the importance placed on the three main design parameters. Under DTC, performance, schedule and cost

were considered equal. In actual practice, more emphasis was placed on performance and schedule than on cost.

Early DTC guidance established only a cost goal based on unit production costs even though lifecycle costs were supposed to be considered in the cost control program. Only years later was a design-to-operating and support cost (DTOSC) goal initiated. However, most programs still implemented only cost goals based on production costs. After milestone I, cost goals were point estimates.

A team approach is also used under the CAIV concept to establish cost goals. In this case the team approach is continued throughout development. The user and contractor are involved in the activities of the team throughout the process. The CAIV process recommends a "business-like" approach to cost management. The techniques that industries use to set cost targets are described in chapter 3. These techniques offer the government a more structured approach to goal setting and the tradeoff process. These techniques allow the emphasis to be placed on the actual cost of a system or component throughout the process. Cost takes precedence over performance and schedule, providing that the minimum technical requirements are achievable.

The CAIV guidance emphasizes that minimum life cycle cost is the primary goal of the efforts. Unit cost goals include both the production phase and O&S phase. Existing guidance recognizes the uncertainty inherent in any cost estimate and allows a

cost goal to be implemented as a range. The percent variability in the goal decreases as the program progresses. Figure 4.1 provides a graphical representation of the acceptable ranges of CAIV goals at the different milestones.

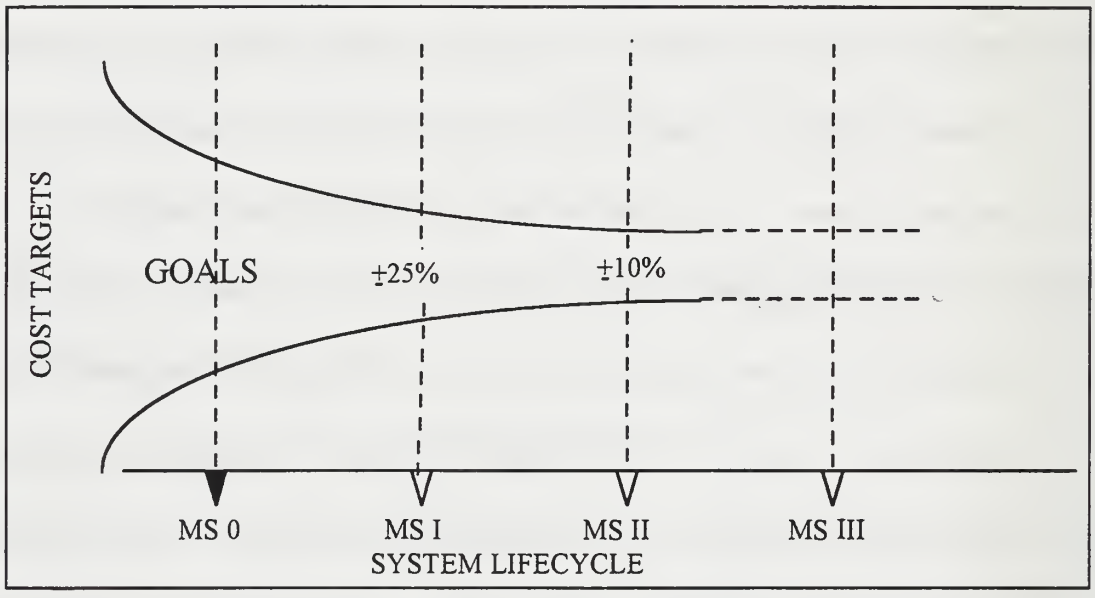

Figure 4.1 Cost Target Ranges [Ref. 28]

2. When Are Goals Implemented?

Both the DTC and CAIV programs recognize the importance of establishing goals early in the program lifecycle. Initial goals are established prior to milestone I and are updated at future milestone reviews. Firm goals, represented by point estimates, are usually set at milestone I for a program under the DTC concept and are required by milestone II. Under the CAIV concept, goals are updated at each milestone and expressed as ranges.

3. How Are Goals Incorporated Into Contracts?

Under the DTC program, the RFP could specify a cost goal or the contractor could propose a goal. Goals were included as part of the demonstration/validation phase (now PDRR) contracts. The government developed MIL STD 337 for the DTC program which included implementation requirements and reporting requirements. Early DTC implementation included only unit production cost goals. One of the requirements that MIL STD 337 imposed on full scale development (now EMD) contracts was to require goals for O&S costs.

Under the CAIV concept, the government and/or contractor establish cost goals for production and O&S. The contractor is a member of the CPIPT and has significant input in the tradeoff analyses that are performed to attain the goal. The government does not reference MIL STD 337 as a result of acquisition reform and instead, must include unique reporting requirements as part of the RFP.

4. What Incentives Are Used To Motivate Government And Contractor Managers?

Competition is considered the biggest motivational factor available to incentivize the contractor to achieve cost objectives. The impact of competition, both positive and negative, is discussed later in this chapter. The CAIV concept also mentions that competition within different mission areas in the DOD is possible. Potential government competition is also discussed later in this chapter.

Under the DTC concept, the RFP specified the relative weights that were to be applied to cost and performance during the source selection process. The CAIV concept, in theory, places a greater importance on cost than under the DTC concept. Source selections should also consider lifecycle cost under the CAIV concept. Lifecycle cost also was a factor under the DTC concept but was rarely a factor with enough importance to change a program decision.

Financial incentives have been important elements of both DTC and CAIV. Incentives are discussed later in this chapter. Although rarely used, program termination has also been considered an option for programs failing to achieve cost goals under both cost control approaches.

5. How Is The Status Of The Program Monitored?

Cost goals are contained either directly or as lower level elements in government program management documentation. The APB, SAR and DCP are some of the documents that contain unit cost goals. The APB usually contains goals based only on development and production costs.

Under the DTC program the contractor provided a formal monthly or quarterly DTC report as required by the contract which was used to monitor progress toward achieving the cost goal. A program initiated under the CAIV concept includes contractor representation on the CPIPT. Through the CPIPT, the program office should always have a current status of the contractor's progress toward achieving the

goal. Continual involvement by government and contractor in the tradeoff process allows for a feed-forward approach to program monitoring rather than the feedback approach dictated by the DTC reporting process.

6. What Happens When A Program Cannot Achieve A Cost Goal?

Programs operating under the DTC concept usually increased cost of the system and the required performance of the system remained unchanged. Under DTC, the contractor's goal specified in the contract was rarely increased and the contractor continued to manage and report to an unachievable goal.

Program termination is one option which is available to the government when a cost breach occurs under both cost control concepts. This option was rarely taken in the past. The other alternatives are to increase the cost goal or to reduce the required performance. A formal higher headquarters review is required to implement either of these changes.

7. How Does The Cost Goal Relate To The Budget?

As DTC evolved, the process provided some guidance to relate goals to the budget. The guidance omitted discussion of risk funding which most program managers included in the cost estimates that were provided for budgetary purposes. This became necessary due to the failure of programs to achieve the contracted DTC goal. The DTC Joint Implementation Guide originally intended that the DTC goal be

representative of the flyaway cost portion of the production budget. The O&S cost goals were not directly related to the project manager's budget.

The CAIV goal represents the cost of the particular hardware element in the budget. The CAIV process recognizes that the cost estimating is not an exact science and as previously discussed includes range estimates for goals or at least recognizes that a program that actually achieves a cost within 10% of a point estimate is still considered a success. The cost target provided to the contractor may be a single number. The program manager should request a budget that allows the most likely actual cost to be fully funded.

8. What Organizations Are Involved In The Process?

Similar organizations are involved in the cost control process under both the DTC and CAIV concepts. The early DTC guidance stated that after milestone I and a program manager was chosen, that the original team which included user representation was disbanded. Cost control usually centered on the efforts of each individual program office. The user remained involved throughout EMD, but his focus was primarily directed toward system performance rather than cost, especially during OT&E.

The user is involved as an active participant in the tradeoff process on a more continuous basis under the CAIV concept. When asked about the differences between DTC and CAIV, one CPIPT member from an Army Program Office, stated the

"biggest difference was that under the CAIV concept the user is continually involved in the tradeoff process along with the program office and contractor." [Ref. 29] The CPIPT has the authority to make tradeoffs as long as performance does not fall below the minimum acceptable level. The CPIPT structure and activities permit a formalized method to continually focus on reducing costs. The DTC process usually didn't involve a dedicated cost reduction team on a continual basis.

C. IDENTIFICATION OF ISSUES

Case studies, lessons learned, reports, briefings and other written information provide numerous examples of problems encountered by offices implementing DTC. Published material and interviews highlighted some areas that may impact successful CAIV implementation. This section will group similar issues, describe each issue, identify the impact and describe potential methods to minimize the impact.

1. Setting The Goal

The first group of issues result from the goal setting process. There are difficulties estimating the costs not only of technologically advanced weapons but also the costs of less challenging systems. Other factors, like an unrealistic schedule, budget fluctuations, production quantities, or even competition often cause major problems for the cost estimator. The specific issues are:

- Point estimates
- Unrealistic cost goals

- Competition
- Unrealistic schedule
- Quantity covered by goal
- O&S cost goals

a. Point Estimates

A cost goal based on a point estimate was not considered the overriding problem. The greater problem was that under DTC the cost goal appeared locked in concrete. This was demonstrated by the fact that a contractor's goal was not usually updated even after it was determined unachievable. Once a goal was determined unachievable, the DTC program became more of an after the fact reporting process. The DTC effort involved reporting what factors caused the variance between the goal and the current estimate.

The CAIV concept recognizes that targets based on range estimates are more achievable than targets based on point estimates. Even though a contractor may receive a point estimate as a goal, the CPIPT process allows the goal to be updated more easily based on changes to quantities, inflation rates, additional requirements, etc. One of the questions that was asked of program office and cost analysis personnel was, what type of cost goal have you experienced under CAIV? Most respondents familiar with CAIV stated that the contractor's goal was a point estimate. [Ref. 29], [Ref. 30], [Ref. 31] The CAIV process allows more flexibility than the DTC process

setting a goal. A cost specified as an allowable range or a process that recognizes the potential inaccuracy of estimates early in development should minimize concerns in this area.

b. Unrealistic Cost Goals

The following paragraph describes the feeling in the defense community with respect to program costs and cost realism:

> Conventional wisdom has held that cost estimates are systematically biased (low) because of the intense competition between new programs for resources and the competition to win new contracts. Thus, industry is expected to underbid the true cost of the program, and the services are expected to accept such a bid as reasonable. [Ref. 32:p. 34]

The experience of personnel interviewed also showed this fact to be true. Military program managers reviewing two major Army systems reduced the original cost estimates prepared by in-house or command cost personnel prior to presentation to the Army. Their job does require the review of these estimates and errors should be corrected prior to submission up through the chain of command. However, the main problem that was found with the estimates was that they appeared too high. The cost analysis personnel then were required to go back and reduce effort in certain areas to develop a more politically acceptable figure. As in most cases, the original estimates for these programs were prepared by reviewing actual cost from previous similar systems or by involving engineers from the functional areas to estimate manhours and materials using a bottoms-up approach. The estimates that

went forward were not consistent with actual past history or the engineer's best estimating efforts. Costs on both programs were higher than the original estimates causing large overruns to the presented estimates. The programs were technologically challenging and were considered successful even after experiencing large cost and schedule overruns.

The competition for programs and funds is also listed as one of the issues and is discussed later in more detail.

> The reduction in the defense budget may aggravate the problem of unrealistic estimates. "As the industrial base shrinks, the surviving companies--hungry for work--will be tempted to "buy-in" to contracts just to keep their workforce employed." [Ref. 33:p. 32]

Losses in the short term are acceptable to the contractor if the long term cost impact is favorable. In the case of cost-plus type contracts, the contractor is only giving up profit.

The use of contractor past performance in the source selection process should lead to a reduction in underbidding in the long term. A May 1996 Report of the Defense Science Board Task Force on Defense Acquisition Reform stated that contractor prior performance should receive heavy consideration during the source selection time frame. [Ref. 34:p. B-5]

Other factors also contribute to unrealistic cost estimates. A new program may require the development of technology that is beyond the state of the art. Historical estimating methods and databases cannot accurately estimate this type of

system. Somewhere along the line, the cost estimator will have to rely on a complexity factor provided by engineering personnel to relate old system technology to the new system. For some cost models, a small change in the factor can significantly change the resulting cost. The CAIV process can account for these changes by allowing goals to be stated as ranges. As the system becomes more defined, the allowable range decreases.

c. Competition

Competition, in this case, refers to the negative aspects of competition that can impact the goal setting process. As mentioned in the previous section, competition can cause program costs to be understated by both the government and contractor management. This was also a problem under the DTC concept. The phenomena was described in 1976 paper by Eugene Johnson, the manager of the Design-to-Cost Laboratory of Boeing Aerospace Company. Figure 4.2 graphically depicts the problem.

If the customer planning estimate, point C, refers to the earliest government estimates, the chart is still representative of the acquisition process today. If point C represents the estimate that is prepared for the milestone decision, experience of persons interviewed has indicated that the negotiation process, line CD, results in a contract award below the government estimate at point C. The situation presented by

Figure 4.2 will remain an issue as long as the acquisition process does not develop procedures to discourage or penalize such practices.

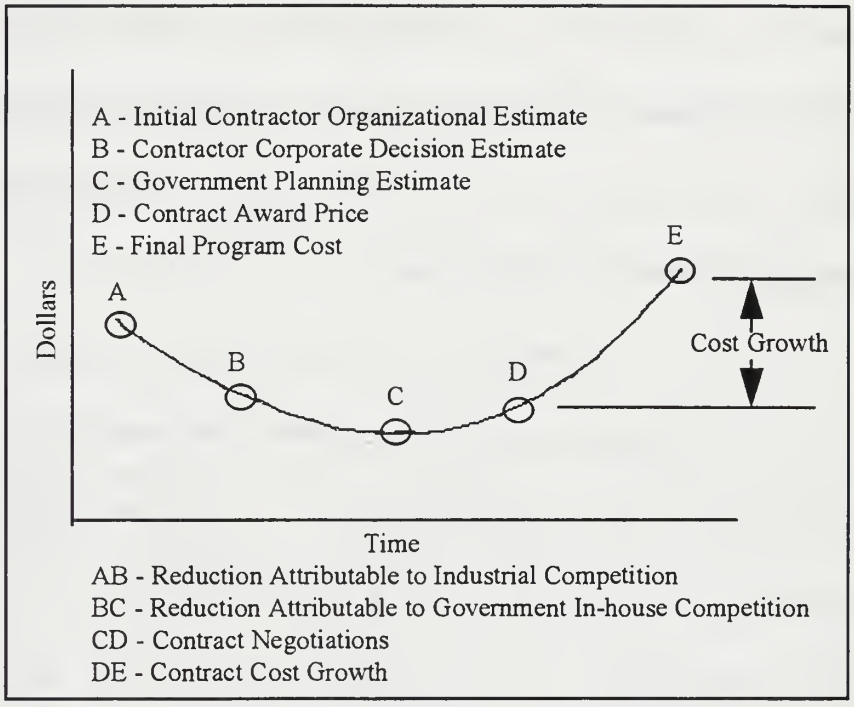

Figure 4.2 Typical ProgramCost History [Ref. 34]

d. Unrealistic Schedule

An unrealistic schedule is considered a significant factor contributing to cost growth in programs. In most cases, schedules are dictated from higher authorities within the government. Both the government program manager and the contractor manager must develop a program plan based on meeting the schedule. An unrealistic schedule leads to program stretchout. The results of an Institute for Defense Analysis (IDA) analysis of 89 defense department programs indicated that program stretch is a

significant factor contributing to both production and total cost growth. [Ref. 35:p. V-2] The use of unrealistic production schedules is discussed further in the next section.

The need for longer, realistic schedules was recognized in the 1970s. An NSIA Design-to-Cost panel stated:

> The acquisition cycle must allow time during concept definition and development phases for thorough trade-off analysis.... In our haste to meet requirements timetables, we invariably take more time in the long run to correct our mistakes and pay dearly for this, not only in the cost to correct mistakes but in the price of the system, because the system procured didn't have the benefit of proper trade-off analysis. [Ref. 36:p. 2]

The DTC process required tradeoffs of cost, performance and schedule. In most cases the schedule was provided in advance and actually could not be used in the tradeoff process. "Schedule is paramount, and resources -- in terms of money and people -- are planned to solve problems in an effort to hold schedule." [Ref. 37:p. 14] This not only requires extra costs and time to correct mistakes as mentioned in the previous paragraph but also requires additional costs throughout the development process to attempt to maintain schedule. Parallel design efforts may be required to enable a system to meet all internal milestones to proceed to the next step in the development process.

The CAIV process may allow a CPIPT to trade schedule versus cost. Another factor also contributes to a willingness to allow these trades. In the past, new systems were developed based on an urgent need. Today there is no longer the same

threat, and urgency of need is no longer considered an overriding factor at the OSD level. A delay in fielding is no longer considered a valid justification to avoid a budget cut.

There are a number of potential solutions to the schedule problem. The government could dictate solutions to the contractor by providing a number of different schedules that could be traded for different costs. [Ref. 38:p. 5] The contractor could then present a proposal using the cost/schedule mix that he could meet. Another option is described by the following paragraph;

> Unrealistic schedules automatically build in problems for the contractor. An option always ought to be open to the contractor in the proposal phase to bid a realistic schedule without penalty (not winning the contract) when compared to a contractor willing to say he can make the schedule when he knows he cannot. (Look at the history of schedules and performance against schedules). [Ref. 38:p. 15]

The use of past performance during source selection should help alleviate the problem by awarding to contractors with a history of achieving the agreed to schedule. Since most previous acquisitions dictated schedules, it will take a number of years to collect the database.

e. Quantity Covered By Goal

The DTC process usually included the entire projected buy in the development of a unit cost goal. The contractor's DTC plan included adjustments that would be required to update the goal based on using the current quantity profile as a

basis. A problem occurred every time the assumptions used by the contractor to estimate quantity changes were not detailed enough to cover the actual change in the quantities. Some programs experienced drastic quantity reductions of 50% or more. Other programs maintained the originally projected quantities but the number of production years increased significantly. The most difficult type of situation facing cost estimators included a combination of both of the above.

Some program goals included only recurring costs. Even if the recurring cost was adjustable based on the new profile, the assumptions used by the program offices to calculate nonrecurring costs might have been wrong. In the past the government usually directly paid for the facilities. If the budget was cut by 50% a much greater reduction in quantities might have been required.

The CAIV process allows goals to be based on quantities which do not reflect the entire buy. The CAIV Working Group guidance states:

> Production cost objectives should be expressed in terms of some reasonably stable measure, such as an early fixed production quantity (e.g., the first production lot), to eliminate variations due to future changes in the quantities planned or actually produced. (For some programs, it may be appropriate to specify the objective in terms of "first unit production cost.") [Ref. 5]

This should help program managers avoid complex adjustment clauses that were common under DTC.

f. Operating And Support Cost Goals

As previously mentioned, O&S cost goals frequently were not used in past programs. An O&S cost goal would face the same problems described above relating to point estimates, unrealistic estimates, unrealistic schedules, competition, etc. The O&S phase is farther out in the future and hence more uncertain. Most programs already include goals for reliability and maintainability (R&M). The Reliability Design Handbook prepared by the Reliability Analysis Center states:

> A review of logistics support cost factors indicate that they are driven by system R&M characteristics. For example, when considering maintenance costs, the reliability of the system and it's components, in terms of unscheduled maintenance frequencies and [mean-time-between-failure] MTBF, directly impacts the frequency of repair and/or overhaul of failed components. Also, the higher the reliability, the lower the number of field modifications required and the lower the cost, including retrofit. Significant R&M expenditures during the development phase can be cost justified if improved field R&M performance and lower operating and maintenance will result from the R&M efforts....Defining limits for trade-off of R&M parameters is of a critical importance. The unit production price limits the cost of spares, the amount of built in test equipment (BITE), and the level of functional reliability that can be designed into the system to meet the operational availability requirement. The operational scenario, along with the unit level reliability, defines the expected number of system faults which will have to be serviced within the defined ownership costs. Required system availability further constrains reliability and establishes the maintenance and supply considerations that will have to be designed into the system. All these factors, and more, enter into the initial design trades if affordable systems are to be acquired. [Ref. 39:p. 284-287]

A detailed cost model is required to effectively perform cost/performance tradeoffs and also model the impact of various reliability, maintainability, and availability values

on the overall cost. The ideal output of such a model comparing reliability and acquisition cost is shown in Figure 4.3.

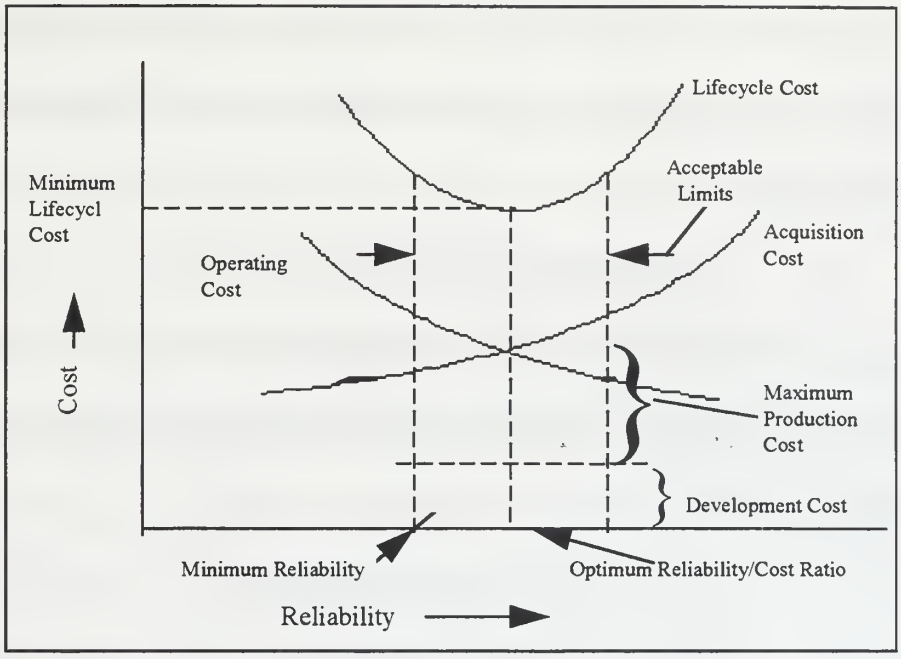

Figure 4.3 Relationship Between Reliability and Cost [Ref. 39:p. 289]

The chart drives home a major point. "For a given design, the cost increases (usually exponentially) as reliability is improved." [Ref. 40:p. 31] To increase reliability without increasing cost requires either a simpler design or a different production process. The chart also provides an indication of the difficulty in developing and managing O&S cost goals. Although R&M may drive O&S cost, many factors influence the costs and a similar tradeoff chart could be prepared for each one. The task is many times more complex than setting and managing to achieve a production cost goal.

The CPIPT process includes logisticians early in the process. Logisticians will have to ensure that R&M requirements are flowed down to the component levels. A detailed cost model is also required to accurately model logistics factors. The Reliability Analysis Center concluded that logistics costs are driven by system R&M.

2. Setting Cost Goals Early In The Cycle

The second area of issues dealt with the setting of cost goals early in the development cycle. Two areas are discussed; setting cost goals too early and setting cost goals too late.

a. Setting Cost Goals Too Early

The design-to-cost goals must be set early where the maximum use of tradeoffs can be made. This belief is held by most government and industry personnel, however, the following paragraph describes the problem with setting an early goal;

> DTC may result in goals being established too early. DTC forces the program manager to commit to a DTC goal well before final agreement on configuration and operational requirements. Hence, the need to "sell" the program may drive DTC goals down to unrealistic levels. The key to the success of the DTC concept is the early determination of a specific cost goal; however, it may be extremely difficult to maintain a goal established so early in development. Tradeoffs are made. Test results may change the direction of development.... Planned production rates may change.... All of these items could drastically affect a goal based on a paper assessment. So one of the cornerstones of DTC itself represents a significant weakness of the concept. [Ref. 35:p. IX-3]

Both the DTC and CAIV concepts state the necessity of setting an early goal. In both cases, goals for a system are sometimes set prior to a program falling under a program manager. The program manager has no input in developing the original goal or system concept. The acquisition process should allow involvement of a program manager representative or program executive office representative early in the process.

The CAIV process mitigates the risk associated with setting an early goal by allowing goals to be stated within a 25% band early in the program. The DTC process did not use ranges and therefore resulted in many goals becoming unachievable early in development once a design was selected.

b. Setting Cost Goals Too Late

The major problem that many DTC programs faced was implementing the cost control program too late in the development cycle. An IDA study of 89 programs determined that DTC was not effective in controlling costs. The study found that DTC was added too late in the process to be cost effective. The study concluded that a DTC goal must be established early to make maximum use of the tradeoff process. [Ref. 35:p. IX-14] This was the most common finding among the literature studied that related to the setting of cost goals.

The CAIV and DTC processes both have procedures and guidance in place which requires the early setting of a goal. The DOD 5000 series (March 1996) guidance specifies the use of CAIV principles throughout the development cycle.

3. Cost Control Program Contract Implementation

The next set of issues center on how the cost control program is implemented in the contract. The issues described in this section include: weight placed on cost in the RFP, implementing O&S goals in contracts, competition, and incentives.

a. Weight Placed On Cost In The RFP

The problem in the past was the lack of importance placed on cost in the source selection process. The emphasis placed on the parameters used to evaluate contracts is summarized by the following comments from an Air Force General, "The competitive environment for defense contracts has been such as to reward innovative designs which provide for high levels of performance through advancements in the state-of-the-art." [Ref. 36:p. 1] An IDA study stated:

> System performance is still the first priority. Traditional emphasis on performance and schedule resulted in a relatively low priority being given to cost. [Ref. 35:p. IX-3]

The technical performance of a system was the most important factor in selecting a contractor. Schedules, as discussed previously, were dictated by the government. The cost was the end result of the dictated schedule and the required performance.

The CAIV process directs that cost play a significant role in the acquisition process. Contracts should be awarded based on meeting required performance at a minimum cost. In many cases all the contractors that bid are technically capable and cost may prove to be the deciding factor. Selections should emphasize getting the "most bang for the buck" and not just the most bang. Best value is a term used to describe the new acquisition approach.

b. Implementing O&S Goals In Contracts

Some of the problems encountered in implementing O&S goals into contracts were previously discussed. A complex model is required to accurately estimate costs. The following paragraph summarizes some of the problems encountered modeling O&S costs:

> The prime reasons why this relationship between production, operating and support costs is so difficult to handle are centered in the lack of uniform definitions and cost accumulation systems which can effectively estimate future operating and support costs. The best way to handle this problem at the present appears to be the use of performance parameters such as meantime(sic)-between-failure, meantime-to-repair, maintenance-manhours-per-operating-hour, or maintenance-turn-around-time-per-mission. [Ref. 41:p. 10]

The previous discussion of O&S indicates that R&M drives most O&S costs and is a valid starting point to implement an O&S goal. The parameters described by the preceding paragraph are all more understandable and measurable than cost elements and relationships. By intensively managing and incentivizing O&S parameters, lifecycle costs can be reduced.

c. *Competition*

Competition as described in this section, relates to the impact of competition on the cost control process. The following paragraph highlights the findings relating to competition:

> Preferably two contractors should be continued through development unless the particular system is so large and the number to be produced so small that the cost of continuing competition through this phase is considered unwarranted. The obvious and extremely important advantage of continuing competition through this phase is that it permits final selection for production to be made when the facts are really known....This approaches also eliminates or substantially reduces the motivation for contractors to buy-in in the development phase because of the lack of assurance of winning the production follow-on. It also provides strong motivation during development to achieve the lowest possible production price. [Ref. 36:p. 2]

In an earlier section, the tendency of contractors to buy-in was one of the causes of unrealistic estimates and goals. The above approach really would not reduce the tendency to buy-in unless the program uses other incentives. Incentives are discussed later, however, the use of past performance as a source selection criteria should help minimize the buy-in tendency. Maintaining two contractors throughout development is considered too costly for many programs.

Competition in earlier phases of development also has positive impacts on a program. Competition at that point [during design and development] has the advantage of allowing the exploration of different alternatives. [Ref. 35:p. VII-1]

Early competition may allow the program manager to achieve the maximum effectiveness from the use of the tradeoff process.

Competition must also be looked at from the standpoint of government/industry teams. A "business-like" approach to acquisition, recommended by higher headquarters does not rely on the constant threat of competition. One of the problems implementing competition in today's acquisition environment is discussed below:

> There may be long-term weaknesses of competition with respect to the relationships between industry and the Department of Defense, but little attention has been paid these issues. Are the benefits of competition a one time effect, or can they be sustained over time? Production competition in major systems must be viewed as an investment decision. [Ref. 35:p. V-II-3]

One Army program office developed an acquisition approach that allows the program manager to develop a long term relationship with the contractor, using a sole source contract, but still maintaining the threat of competition. The JAVELIN Project Office developed a cost reduction plan (CRP) as a formal agreement between the contractor and the program office. The CRP was signed by the Army Acquisition Executive (AAE) and high levels of contractor management. The program office established a cost estimate based on the savings that might be obtained from competing the two partners of the Joint Venture. Contract cost goals were established for each year in the production program. The contractor was provided the estimated funding available each year for hardware and services. The contractor could achieve

the savings required to meet the funding levels through acquisition reform initiatives and other "business-like" techniques. As long as the contractor's production proposal was negotiated below the cost curve, there would not be competition. The first three years were signed at or below the curve.

OSD also agreed to the CRP by signing the Program Baseline document which incorporated the CRP cost profile. The CRP has an underlying assumption that the program would receive its full budgeted amount. The CRP was also used successfully to defend the program from adverse Program Budget Decisions (PBD).

The CRP provided a difficult but realistic yearly cost goal, ensured management support and emphasis, included producibility enhancements to reduce production and O&S costs, and enhanced contractor and government teamwork. The signed agreement listed assumptions and ground rules which formed the basis of the government and contractor cost estimates.

As long as the contractor's yearly proposal or negotiated cost was below the costs specified in the CRP, the program remained sole source. This approach required some significant changes to the normal government/contractor relationship and to the way the Army conducted source selections. The positive benefits of competition and government/contractor teamwork are both achieved.

History shows that the threat of competition can achieve the same benefits of competition. The following example from the HARM program attests to this fact.

> In the HARM program, lower prices from the threat of competition resulted in a decision not to dual source. Incumbent, Texas Instruments dropped its price by $209 million for the period FY1983-85 and by $1.2 billion for the period FY1983-89 in order to stay sole source. [Ref. 35:p. VII-5]

The new acquisition environment outlines another approach to competition. A Defense Science Board Task Force stated:

> We recommend maintaining alternate solutions to mission needs among supplier agencies as well as among contractors, with continuing participation and evaluation by users. It must be emphasized that we are proposing a broader form of competition than two firms building the same product. Competition could be among different solutions to the same problem including current system upgrades versus next generation systems. [Ref. 42:p. ii]

This type of competition can involve the Services competing against one another to provide support. The approach recommends maintaining the possibility of competition throughout the product development cycle. Competing based on mission needs is discussed further in Chapter V.

d. Incentives

Contract incentives in EMD and production were associated with lower cost growth. [Ref. 35:p. V-7] This is the same result found by other studies. The IDA study explained that the incentive clause can be used effectively with the DTC

program. The incentive was the "enforcer" of the DTC provision in the contract. As an example, IDA found on the F/A-18 program, the DTC program was taken more seriously than on other programs. Other programs placed little emphasis on DTC. [Ref. 35:p. XI-2]

The amount of the incentive is also an important factor in determining whether or not a contractor will meet cost goals. A GAO study reviewed 62 fixed price incentive contracts from the 1977 to 1984 time period. The study results indicated:

> The GAO found a clustering of final prices close to the target price and an increasing tendency for final prices to underrun the target price as the contractor share ratios were increased. Overall findings were that final contract costs and price seemed unrelated to the sharing ratio. [Ref. 35:p. XI-3]

Based on the results of the GAO study, guidelines can be developed to assist in developing an incentive arrangement. The following guidance is provided:

> Consider large profit incentives (20-25%) during the development phase with the incentive tied to the achievement of production price and life cycle cost factors stated in the specification. These incentives will be more than recovered during the production phase and would be a very strong motivation to industry management. [Ref. 36:p. 3]

Many of the factors discussed throughout this chapter require additional development funding. The OSD also recognizes the possibility of development costs increasing, with savings achieved in the production and O&S areas.

e. Development Contract Type

It was generally agreed in most of the literature on contract type that, "cost type contracts should be used to the maximum extent possible during concept definition and development phases. Fixed price contracts motivate against good trade-off analyses." [Ref. 36:p. 2] Fixed price development contracts encourage the contractor to minimize costs on the current contract and not look at future costs.

4. Budget Instability

The instability of the federal government budget process leads to an inefficient use of resources within the DOD. Budgets are planned based on a long period of time. However, Congress appropriates funding on a yearly basis. Then, both OSD and military departments and the Service can withhold or reprogram a certain percentage of the funds. The individual program rarely receives the amount of funding that it anticipated based on the previous year's budget estimate. This chapter discusses three areas: (1) the direct impact of budget instability , (2) the indirect impact, and (3) the Congressional impact.

a. Direct Impact

In "Affording Defense", Gansler describes the typical Service approach to managing a budget reduction. The author states:

> The Service...starts off assuming that a certain number of dollars will be available with which to produce certain quantities of various weapon systems. Then, typically, the total obligational authority is reduced -- often by the President first, then by Congress. The proper way to handle such a budget cut, in order to maintain the efficiency

> of the remaining programs, would be to assign priorities and then to defer or cancel enough lower priority programs that the cuts could be absorbed. Historically, both the DOD and Congress have been reluctant to cancel programs; the approach has been simply to buy fewer units of each system "this year" and to stretch out all programs, hoping to purchase the rest of the units in later years. [Ref. 43:p. 122-123]

Previous sections described the cost implications of stretching out programs. The impact on production costs is widely known and discussed in literature. The impact of budget cuts on the development program has an obvious result of potentially stretching development, but also reduces the funding available for tradeoffs. Both the DTC and CAIV concepts require early tradeoff analyses to minimize downstream production and O&S costs.

b. Indirect Impact

A fluctuating budget and yearly appropriation of funds cause other impacts that are hard to measure. The following paragraph from an Executive Research Project reveals the impact of the problem.

> T.A. Wilson, former Boeing Chairman of the Board, [in a] presentation to the President's Blue Ribbon Panel in 1986 compared commercial practices to military procurements. He stated that Boeing often commits hundreds of millions of dollars in training and long lead high productivity machinery two or more years before go ahead. "The message being emphasized in these remarks was that the uncertainty of government programs constituted a major deterrent to similar anticipation of capital investment and training in support of defense production." In other words, with the short one year planning cycle in the federal budget cycle, significant company investments in technology to improve the process are not encouraged. Short term budget horizons will continue to foster

> business as usual attitudes in military aircraft development. [Ref. 37:p. 25]

This statement indicates that even by adopting a "business-like" approach to acquisition, short planning cycles will cause the government not to achieve the efficiencies realized in the private sector. The DOD can alleviate some of the problem by entering into multiyear contracts. A multiyear contract type is usually not implemented until a program is in full rate production. The investment that Wilson describes occurs well before that time period.

c. Congressional Impact

Congress can either directly or indirectly impact a program. The impacts described above may be attributed to Congress. However, congressional impact is listed as a separate category to emphasize the substantial effect Congress has on programs.

The following statement from a study on DOD weapon system cost growth summarizes the findings of most research. "The budgetary process isn't a strict exercise in efficient resource allocations. Many decisions are based on political considerations vice strict resource allocations considerations." [Ref. 33:p. 32] Some authors were more specific and narrowed the cause of the problem to a specific group in Congress. "The Congressional Majority Party has a significant impact on cost and schedule growth." [Ref. 44:p. 4]

Another disturbing finding is that as DOD increases the use of commercial practices, Congress has increased program oversight. [Ref. 37:p. 3] Congressional micromanagement requires program managers to spend more time defending and justifying their programs. More time spent preparing responses and briefings to Congress allows less time for actually managing the acquisition program.

Unless the CAIV program can adapt procedures to minimize the impact that unstable budgets have on the acquisition process, cost control and reduction will be difficult. Previously, the CRP was mentioned as one device that could help establish a longer term relationship with the contractor while also maintaining the control and accountability required by Congress and the General Accounting Office (GAO).

5. Management Issues

A number of factors may cause failure to achieve a cost goal. Previous sections described the tendency of programs to understate initial costs. Of course, this leads to cost overruns. However, even programs with a realistic cost goal may often fail to achieve the desired results. This section discusses areas all of which contribute to the inability of a program to achieve the cost goals: management support, flexibility, unnecessary requirements and lack of communication.

a. Management Support

Previous studies indicated that without top management support, a DTC program cannot achieve the expected results. A paper by the National Security Industrial Association Research & Engineering Avisory Committee, titled "How to Motivate Teams to Design to a Cost", found a correlation between management support and DTC program success. It states: "The degree of success that can result from a Design-to-Cost program is heavily dependent on the degree of management support given the program." [Ref. 38:p. 3] Other research also supports this finding. A study conducted on the Navy F/A-18 Program concluded, "The contractor did not perceive the Navy as placing sufficient emphasis on DTC." [Ref. 45:Vol. 1, p. E-6/7] If the Service does not place sufficient emphasis on cost control, neither will the contractor. The contractor will place emphasis on the program elements that the customer considers important.

A 1989 IDA study developed the following conclusions regarding DTC:

- In most programs, the DTC goal was not followed through to completion. It either was dropped or faded away in program EMD.
- DTC has been used mainly as a cost-monitoring device in EMD rather than as a tool for making tradeoffs earlier in the process.
- There has been an absence of continued technical evaluation of design/effectiveness/cost tradeoffs earlier in the process.

- Use of data and feedback on DTC has not been sufficient to encourage contractor emphasis on DTC programs. [Ref. 35:p. IX-3-13]

Lack of emphasis on the application of DTC by the government is a common thread linking the above conclusions. The CAIV concept will face similar results without proper emphasis. As discussed in the last chapter, the "business-like" approach using QFD, strives to place emphasis on program elements that are considered important to the customer.

b. Flexibility

The CAIV concept requires flexibility in the system to allow the contractor/government teams to recommend cost/performance tradeoffs.

The DTC concept also mentioned flexibility as one of the key features required for successful implementation. The 1983 Joint Design-to-Cost Guide characterized the need for flexibility as follows:

> The PM and each competing contractor must have maximum freedom to provide their version of the best possible design to perform the mission at the established cost goal. This requires that the unit production cost goal be related to...only the minimum number of essential performance requirements (speed, range, payload, etc.). This will allow the PM and contractor the flexibility needed to make tradeoffs among cost, schedule and performance (including maintainability and reliability). [Ref. 47]

The Joint DTC guide went one step further in describing the latitude that contractors should have to enable them to achieve cost goals. The guide stated that contracts should be structured to allow the contractor to recommend the deletion

of performance requirements and specifications if they are proven to have no value added. [Ref. 47:p. 49] The number and detail of specifications actually increased over the years. Acquisition reform guidance provides a mechanism to reduce the specifications which is a requirement to fully implement the cost control program.

Other guidance from the seventies stated that the government should provide ranges of acceptable performance characteristics and schedules to the contractor. The contractor can then trade cost for performance or schedule. [Ref. 38:p. 5]

Another finding from a study of the F/A-18 program was that ,"the contractor did not perceive the Navy as being willing to trade other system parameters, for example, performance for cost." [Ref. 45:Vol. 1,p. E-6/7] If the schedule and performance were fixed, cost was the only element that could vary. Costs generally increased, not decreased. Under the CAIV approach, the CPIPT actively monitors and performs tradeoff analyses. One person interviewed in an Army program office stated that the program office, contractor and user were all involved as team members on a continuous basis to implement CAIV. The user was willing to tradeoff performance to achieve the cost goal. [Ref. 46]

Current ideas from industry suggest a process to ensure that cost goals are achieved by making cost fixed and varying the other parameters. The Defense

Science Board called this a fixed price, variable performance contract. Performance can be lowered to achieve the cost goal.

c. Unnecessary Requirements

The previous section discussed flexibility as a key requirement for a CAIV program. Industry always mentions unnecessary requirements as another key contributor to cost growth. The following paragraph identifies this problem:

> Implementation of CAIV will solve only part of the problem associated with increasing program costs. Acquisition reform has helped enable cost reductions in other areas. The other areas of acquisition which must be addressed include mission requirements, performance specifications, reliability and maintainability requirements, testing programs, documentation, etc. These areas are not under the control of the contractor's design engineers. [Ref. 38:p. 1]

The use of detailed design specifications to describe weapon systems and components was one of the problems encountered by programs implementing DTC. Dr. Foster stated, "In my opinion one of the most significant causes of high cost designs are performance specifications which dictate high cost solutions." [Ref. 6:p. 17] Acquisition reform has eliminated the problem of programs dictating hundreds of detailed specifications during the development process.

The problem of overstating required performance could still surface. User participation in the CPIPT and new cost estimating methodologies that allow the estimation of the cost of increased performance will help to control this problem. The

QFD process can help the CPIPT to separate mandatory requirements from "nice to have" features.

d. Communication

Poor communication between contractor and government personnel is a recurring problem in the defense environment. Acquisition reform and the CAIV process have reduced the problem. The communication problem has always existed. Under the DTC concept, lack of communication was identified as an area with the potential to greatly impact the effectiveness of the cost control program.

The Design-to-Cost panel stated, "Any practice that prevents information on expected costs from being honestly and openly transmitted between the military Services and contractors will tend to defeat the Design-To-Cost process." [Ref. 38:p. 3] At the time this was considered a departure from normal operating procedures. Procurement related cost information was never exchanged with the contractor. Federal acquisition regulations still prohibit certain costs from being discussed with the contractor. The Army CRP procedures described earlier in the chapter involve direct discussion with the contractor regarding anticipated contractor funding levels and costs. Implementation of the CRP requires the open exchange of the government's estimated costs. This is certainly a departure from the past way of doing business.

The tradeoff process requires communications with the contractor to enact changes in a quick and efficient manner. The CPIPT accommodates this requirement by including the contractor as a member of the team. A proactive CPIPT should also alleviate the perception on the part of the contractor that the government does not consider the cost control program important.

D. SUMMARY

This chapter discussed the issues developed from study of past programs and from personal structured interviews. A summary of the issues is listed below:

- Using a point estimate to represent a goal
- Establishing an unrealistic cost goal
- Negative impacts of competition
- Establishing an unrealistic schedule
- Basing the goal on the entire buy
- Establishment of an O&S goal
- Setting goals too early
- Setting goals too late
- Weight placed on cost in RFP
- Implementing O&S goals in contracts
- Positive impacts of competition

- Contract incentives
- Development contract type
- Direct impacts of budget instability
- Indirect impact of budget instability
- Congressional impact on a program
- Top management support
- Program flexibility
- Unnecessary requirements
- Government/contractor communication

The CAIV concept minimizes or eliminates the impacts caused by some of the issues on program management efficiency. Other issues may still be problems for program managers trying to establish a cost control program based on the CAIV concept. The next chapter provides recommendations for program managers to tackle issues not directly mitigated by the CAIV approach to cost control.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The CAIV concept is similar to the DTC concept. In most cases, DTC was not implemented as the guidance intended. Much of the failure of the DTC program may be attributed to the poor implementation and the lack of emphasis on cost control by managers in the past. Previously, performance was the main criterion used to select a contractor and cost was shaped by all the other programmatic decisions.

At its inception, DTC was based on a "business-like" approach; since then, industry tools and techniques for cost estimating and performing tradeoffs have been refined. Today, the acquisition environment provides significant advantages to the program manager implementing the CAIV concept. Designs are no longer controlled by detailed specifications and tradeoffs are possible. If management provides the required emphasis on cost control, the expected results of CAIV should be achieved. However, without management support, CAIV will face the same fate as DTC.

B. ANSWERS TO RESEARCH QUESTIONS

1. Primary Research Question

What challenges will be faced by the Services in implementing the CAIV concept on new systems? The short answer is that there are a number of issues. These are addressed in answering the subsidiary questions below.

2. Subsidiary Questions

The following subsidiary questions addressed the primary research question:

- What is the difference between CAIV and the DTC program required in the past to control and manage program costs?
- What advantage does the CAIV concept outlined in the updated DOD 5000 series documents offer the Services?
- What systems can be used as benchmarks for CAIV implementation?
- What issues will program managers face in implementing CAIV?
- What recommendations can be offered to program managers to best address problematic CAIV issues?

a. What Is The Difference Between CAIV And The DTC Program Required In The Past To Control And Manage Program Costs?

There were several differences between the CAIV and the DTC program. These differences may enable a program manager to use CAIV to successfully control costs on a program. The notable differences are in the following areas: (1) the emphasis placed on cost during the development process, (2) the goal setting process, (3) the flexibility provided managers, (4) management support and (5) communications between government and contractor.

Performance and schedule now are dependent on cost. In the past, the three parameters, cost, schedule and performance were considered equal. However, the schedule was generally provided. Very challenging performance requirements also were stated. Cost could only become the end result of the process. The stringent requirements did not give the government and contractor the latitude required to perform cost tradeoffs. The CAIV process provides an available tradeoff space. Under acquisition reform, performance goals are stated as ranges and schedules are event driven.

The goal setting process has also changed to allow CAIV to generate more realistic cost goals. Goals may still be directed from higher level headquarters, based on costs of previous systems and estimated using established cost analysis techniques. The CAIV guidance suggests the cost analyst apply techniques used by industry to estimate costs in a competitive environment, including target costing, ABC and QFD. These techniques were not formalized during the period DTC was implemented.

The CAIV process also recognizes that there are many unknowns early in the development phase, and therefore, allows goals to be stated as ranges. The range of the goal would narrow as the program progresses. Goals stated as ranges also provide the program manager an available tradeoff space to better

determine the combination of cost, schedule and performance that provides the "best bang for the buck."

The DTC process usually fixed performance and schedule and only cost could vary. As a result, costs basically could move in only one direction: up. As mentioned in the previous paragraphs, CAIV provides a flexible framework in which to perform tradeoffs. The user and developer must be active participants throughout the tradeoff process.

Management also appears more receptive to the CAIV process. Pilot programs implementing CAIV appear to have full support to test out the process. The new DOD 5000 series documents require that CAIV is a consideration during the milestone review process for all future programs.

The CAIV process also provides for enhanced communications between the program management office, the contractor and the user. A CPIPT approach to cost management and control provides immediate feedback to both the contractor and government. No longer are the communications hampered by delays waiting for correspondence between parties.

b. What Advantage Does The CAIV Concept Outlined In The Updated DOD 5000 Series Documents Offer The Services?

The advantages of the CAIV concept lie in the differences between the DTC and CAIV programs discussed above. The CAIV approach provides a mechanism to set a more realistic cost goal, directs that cost not become the output of

the design process, provides for more flexibility in the process, and opens communication lines between the government and contractor.

The new DOD 5000 series documents include acquisition reform initiatives that provide tradeoff opportunities to managers. Previously the design of most components and processes was dictated by detailed specifications, severely limiting the potential for tradeoffs.

Early interpretations of CAIV guidance also suggest a powerful incentive for Services to manage costs. Under DTC some managers knew they were "the only game in town." The program was "required" at almost any cost. CAIV guidance infers that competition between Services and within mission areas may be required to control programs. If Service managers faced the proposition of losing their programs to another Service, cost control would become a greater concern of managers. Lack of management support was cited as one of the reasons that DTC failed as a cost control program.

c. What Systems Can Be Used As Benchmarks For CAIV Implementation?

There is little history available to analyze the potential success or failure of CAIV. In early CAIV correspondence, OSD requested that the Services nominate programs to become "flagship" programs. The current systems that serve as "flagship" programs for CAIV implementation include: ATACMS/BAT P^3I, Crusader, AIM-9X, MIDS, SBIRS, JASSM and JAST. The CAIV concept is new and the implementation

is only in the early phases. A number of years may be required before CAIV results are known. Several program managers from programs not designated as "flagship" programs also provided examples of dollar savings generated by the CAIV approach. However, the same managers also were unclear on what CAIV was or how it was supposed to work. This lack of understanding can only reduce the chances for CAIV to succeed.

d. What Issues Will Program Managers Face In Implementing CAIV?

The following issues facing managers were identified and discussed by category in Chapter IV:

- **Setting the Goal**
  - Using a point estimate to represent a goal
  - Establishing an unrealistic cost goal
  - Negative impacts of competition
  - Establishing an unrealistic schedule
  - Basing the goal on the entire buy
  - Establishing an O&S goal
- **Setting Goals Early in the Cycle**
  - Setting goals too early
  - Setting goals too late

- **Contract Implementation**
  - Placing weight on cost in RFP
  - Implementing O&S goals in contracts
  - Contract incentives
  - Positive Impacts of Competition
  - Development contract type
- **Budget Instability**
  - Direct impacts of budget instability
  - Indirect impact of budget instability
  - Congressional impact on a program
- **Management Issues**
  - Top management support
  - Program flexibility
  - Unnecessary requirements
  - Government/contractor communications

e. What Recommendations Can Be Offered To Program Managers To Best Address Problematic CAIV Issues?

Several areas are key to successful CAIV implementation. Setting realistic cost goals, management support and communications are areas directly under the control of the program manager. Today's "business-like" environment emphasizes

the government/contractor team as opposed to the often adversarial relationship between the government and contractors in the past. CAIV also stresses that competition is one of the best techniques to control program cost. In the past competition was also one of the causes of cost growth by encouraging understated bids. The emphasis on past performance in the source selection process and the possibility that a Service manager may lose the program to another Service should minimize understating of costs. Now not only the contractor but also the government may face competition.

The CRP was discussed in Chapter IV. The CRP allowed the JAVELIN Project Office to receive the benefits of both competition and government/contractor teamwork. The CRP established difficult but realistic yearly cost goals and ensured management support and emphasis. The cost goals were a target for both contractor and government managers. Once the goal was established government/contractor teams focused attention on reducing costs to achieve the goals.

C. RECOMMENDATIONS

As described in the last subsidiary research question (subparagraph d, above), it is recommended that programs implement CAIV based on a formal agreement with the contractor. The user should also sign the agreement. This agreement should foster the teamwork required in today's environment and could also help minimize the impact of

external program inhibitors, and perhaps improve relations with Congress over the acquisition budget.

D. AREAS FOR FURTHER RESEARCH

There are a number of areas of research that would benefit program managers. Areas include defining better cost estimating techniques, monitoring the CAIV program, case histories or lessons learned and further guidance on the subject of mission area competitions.

1. Defining Better Cost Estimating Techniques

Managers would benefit from further guidance explaining the techniques that industries use to establish cost goals and perform tradeoffs. Detailed examples from industry, describing the QFD approach should be prepared as a lessons learned or an implementation guidebook.

2. Monitoring The CAIV Program

The actual monitoring of CAIV implementation, including metrics was not discussed in this thesis. As more programs implement CAIV, procedures and guidelines will be required to enable managers to track program progress. The JAVELIN CRP process included procedures for tracking progress and may serve as a tool for further research.

3. Case Histories Or Lessons Learned

As "flagship" programs implement and manage CAIV, resulting case studies may prove beneficial to future managers. This thesis developed implementation issues based on comparison to the DTC program. Actual case studies could provide lessons learned and develop issues that may differ from the problems anticipated here.

4. Mission Area Competitions

Mission area competitions or competitions between Services is a new approach to competition. The Service leaders must better understand the implications this type of competition might have on their programs. A Service may lose a program to another Service. A further step would be to investigate whether the current budgetary process could actually accommodate this type of competition and still be effective in providing stable acquisition resource streams for DOD.

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